Iron and Steel Engineer

Established 1907 as Proceedings of A. I. & S. E. E.

T. B. LITTLE, EDITOR

CONTENTS

Vol. XI. DECEMBER, 1934 No. XII

Super-Imposed Steam Turbine-Generator Plants for the Steel Mill—by A. G. Darling, Industrial Engineer, General Electric Company, Schenectady, N. Y. 469

Discussion—Super-Imposed Steam Turbine-Generator Plants for the Steel Mill—Discussion presented by E. W. Trexler, G. T. Hollett, A. G. Darling, J. L. Miller, W. T. McCullough, Jr., E. W. Wagenseil, and J. H. Strassburger 477

In Memoriam—John F. Kelly—by A. J. Standing, Past President of the A. I. & S. E. E. and Electrical Superintendent, Bethlehem Steel Company, Bethlehem, Pa. 478

Oxy-Acetylene Welding and Cutting in Metal Working—by W. S. Walker, The Linde Air Products Company, Cleveland, Ohio 479

Discussion—Oxy-Acetylene Welding and Cutting in Metal Working—Discussion presented by C. O. Franklin, M. J. Henderson, W. S. Walker, A. E. Gibson, C. Simera, and W. H. Moos 484

76" Hot Strip Mill, Inland Steel Company, Indiana Harbor, Ind.—by R. W. Davis, Electrical Engineer, Allis-Chalmers Mfg. Company, Milwaukee, Wis. 486

Discussion—76" Hot Strip Mill, Inland Steel Company, Indiana Harbor, Ind., Discussion presented by S. Badlam, R. W. Davis, L. A. Umansky, F. O. Schnure, C. J. Smith, G. Fox, J. O'Malia and A. J. Standing 490

Load Factor and Power Cost—A Danger and a Possible Answer—by Paul M. Lincoln, Director, School of Electrical Engineering, Cornell University, Ithaca, N. Y. 494

Discussion—Load Factor and Power Cost—A Danger and a Possible Answer—Discussion presented by J. F. Gillespie, Paul M. Lincoln, A. G. Montgomery, Dr. J. Slepian and G. A. Hughes 492

Obituary—The Late G. T. Hollett, Steam and Combustion Engineer, The Illinois Steel Company, South Chicago, Ill. 493

Developments in the Rolling of Sheets and Strip 1934—by Stephen Badlam, Consulting Engineer, Pittsburgh 500

Items of Interest 510

A. I. & S. E. E. District Section Chairmen and Secretaries for 1934-1935 II-III

Index to Advertisers IV

Published Monthly by

Association of Iron and Steel Electrical Engineers

BOARD OF DIRECTORS—1934-1935

President, W. H. Burr, Mechanical and Electrical Superintendent, Lukens Steel Co., Coatesville, Pa.

1st Vice Pres., J. A. Clauss, Chief Engineer, Great Lakes Steel Corp., Ecorse, Mich.
2nd Vice Pres., G. R. Carroll, Elec. Supt., Jones & Laughlin Steel Corp., Aliquippa, Pa.
Director at Large, C. A. Thayer, Chief Engineer, Republic Steel Corp., Youngstown, Ohio.
Honorary Director, J. Farrington, Elec. Supt., Wheeling Steel Corp., Steubenville, Ohio.
Honorary Director, E. Friedlander, Pittsburgh, Pa.
Past President, W. E. Miller, Mech. and Elec. Supt., Bethlehem Steel Co., Johnstown, Pa.
Past President, J. D. Donovan, Mech. and Elec. Supt., Republic Steel Corp., Massillon, Ohio.
Treasurer, W. S. Hall, Supt., Engr. and Const., Illinois Steel Co., S. Chicago, Ill.
Secretary, A. D. Adams, Asst. Supt., Spang Chalfant Company, Inc., Ambridge, Pa.
Director, C. A. Kral, Asst. General Manager, Wheeling Steel Corp., Steubenville, Ohio.
Director, C. C. Wales, Chief Engr., Otis Steel Co., Cleveland, Ohio.
Director, J. L. Miller, Asst. Chief Engr., Carnegie Steel Co., Youngstown, Ohio.
Director, L. F. Coffin, Supt. Mechanical Department, Bethlehem Steel Co., Sparrows Point, Md.
Director, K. E. Dinius, Chief Testing Engr., Illinois Steel Co., South Chicago, Ill.
Director, C. C. Pecu, Lubrication Engr., Bethlehem Steel Co., Lackawanna, N. Y.
Director, E. P. Winters, Power Engr., Sloss Sheffield Steel & Iron Co., Birmingham, Ala.
Director, E. F. Blank, Dir. of Safety and Welfare, Jones & Laughlin Steel Corp., Aliquippa, Pa.
Director, C. H. Hunt, Asst. to Pres., Weirton Steel Co., Weirton, W. Va.

Acting Managing Director, T. B. Little, Empire Building, Pittsburgh, Pa.

Entered as second-class matter January 25th, 1924, at Pittsburgh, Pa., under the Act of March 3rd, 1879.
Subscription Price $5.00 per Year. Single Copy $1.00.

C. H. HUNT,
Secretary, Pittsburgh Section,
Asst. to President, Weirton Steel Co.,
Weirton, W. Va.

C. C. WALES,
Chairman, Cleveland Section,
Chief Engineer, Otis Steel Company,
Cleveland, Ohio

L. F. COFFIN,
Chairman, Philadelphia Section,
Supt. Mechanical Department, Bethlehem
Steel Co., Sparrows Point, Md.

DISTRICT SECTION SECRETARIES OF THE DELPHIA, BIRMING AND CLEVELAND A. I. & S. E. E.

C. R. TINSLEY,
Chairman, Birmingham Section,
Elec. Engr. and M. M., United States Pipe
and Foundry Company, Bessemer, Ala.

C. J. SMITH,
Chairman, Chicago Section,
Electrical Engineer, Illinois Steel Company,
South Chicago, Ill.

H. G. R. BENNETT,
Chairman, Pittsburgh Section,
Assistant General Supt., Carnegie Steel Company,
Duquesne, Pa.

A. J. WHITCOMB,
Secretary, Chicago Section,
Electrical Engineer, Freyn Engineering Co.,
Chicago, Ill.

CHAIRMEN AND MEMBERS OF THE PITTSBURGH, PHILADELPHIA, BIRMINGHAM, CHICAGO AND CLEVELAND SECTIONS OF THE A.I.E.E. FOR 1934–1935

L. O. MORROW,
Secretary, Philadelphia Section,
Electrical Engineer, Philadelphia, Pa.

W. W. SPANAGEL,
Secretary, Cleveland Section,
Reliance Electric & Engineering Company,
Cleveland, Ohio

B. THELE,
Secretary, Birmingham Section,
Electrical Laboratory, Tennessee Coal, Iron
& R. R. Co., Fairfield, Ala.

INDEX TO ADVERTISERS

A

The Alliance Machine Co. 537
Allis-Chalmers Manufacturing Company 522
Aluminum Company of America 521
The Amsler-Morton Company 528

B

G. H. Bales 539
Bussmann Manufacturing Co. 513

C

Carnegie Steel Company 520
The Cleveland Crane & Engineering Co. 531

E

The Electric Controller & Mfg. Co. 524

F

Farrel-Birmingham Company, Inc. 532

G

General Electric Co. 526—Cover 4

H

Hyatt Roller Bearing Company 523

I

I-T-E Circuit Breaker Company Cover 3

J

Jefferson Electric Company 529

L

Ladd Equipment Co. 539
Lewis Foundry & Machine Co. Cover 1

M

Mackintosh-Hemphill Co. 516
The Martindale Electric Co. 538
McGraw Electric Company 513
McVey Hausman Co. 539
Mesta Machine Company 519
The Morgan Engineering Co. 527

N

National Carbon Company, Inc. 537
New Departure Mfg. Co. 517
New York & New Jersey Lubricant Co. 534

P

Pennsylvania Transformer Company 534
Poole Foundry & Machine Co. 539

R

Reitz Sales Co. 539
Reliance Electric & Engineering Co. 533
Rockbestos Products Corp. 536

S

SKF Industries, Inc. 515
Stimple & Ward Co., Inc. 536
Surface Combustion Corporation 525

T

The Thompson Electric Co. 538
The Timken Roller Bearing Co. 540
The Tool Steel Gear & Pinion Co. 518
The Trumbull Electric Mfg. Co. 530

W

The Wellman Engineering Co. 535
Westinghouse Elect. & Mfg. Co. Cover 2

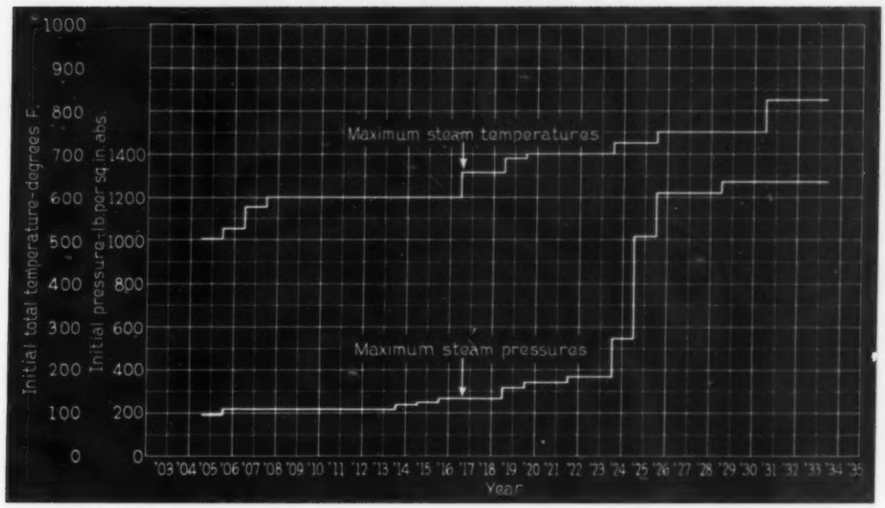


FIG. 1—Chronological Progress by the General Electric Co. in the Use of Higher Steam Temperatures and pressures in Turbines.

Super-Imposed Steam Turbine-Generator Plants For The Steel Mill

By A. G. DARLING
Industrial Engineer, General Electric Company, Schenectady, N. Y.

Paper presented at the A. I. & S. E. E. Annual Convention held in Cleveland, Ohio, September 18, 19 and 20, 1934.

The status of the high pressure steam power plant is such that it warrants the inspection of those industrial plants to which it may be applied with economy. Conservatism as applied to their power plant design has been a characteristic practice of American industry. When developments advanced from the experimental to the practical stage, industry has been prompt to accept the improvements. In many industries, power represents a relatively small part of product cost, consequently high efficiency takes second place to reliability. Electricity has elimnated many difficulties inherent with mechanical methods and, more recently, by its characteristics, electricity has improved the quality of some products, as for example in welding and heat treatment. There still remain many uses for the sensible heat of steam and for power produced locally by steam hammers, rams, blowers, compressors, etc., which, for their characteristics or economies, are preferred by industry. The trend, however, is, in general, toward more kilowatt-hours use per unit of product.

Power plants lose efficiency, both absolutely and relatively, with elapse of time and with improvement in design. Boiler tubes scale and become less heat conductive; turbine buckets gather sediment and develop less kilowatts; new and more efficient ways and means of arriving at the desired result are found, tried and put into general use. It is because of the higher quality of product produced electrically, because of the greater economy and flexibility of electric drive and finally because many industrial power plants warrant new and more efficient equipment, that the results of a power survey are given in this paper.

In the past ten years a number of unknown factors in the design and building of steam boiler and turbine plants have been cleared away, which fact has released more of the energy available in steam for practical use. Represented by steam pressures and temperatures, there has been a steady and, at times, rapid expansion in the use of the available energy in steam. Fig. 1 shows the advancement made when, during the short period of about 30 years, pressures have increased six times their 1903 maximum and temperatures have risen 65%. This is due, in no small measure, to the contributions made by the steel industry. We are now practically at the heat limit of metals whose characteristics are well understood. Developments are under way to carry this expansion to still greater ranges of steam energy and to the use of other agencies, such as mercury. For the purposes at hand, discussion will be limited to higher steam pressure and temperature than are commonly used in industrial plants.

In the field of 1200-lbs., considerable operating experience has been gained since the first turbine unit of this design was built in 1925. Fig. 2 is a statement of 1200-lb. turbine sizes. Notable among this list are the three industrial plant machines,—the 12,500 Kw. non-condensing unit feeding steam and power to the Du Pont Company from the Deepwater

	Kw. Rating	Steam Conditions	Remarks
Chicago Dist. Elec. Gen. Corp. Hammond, Ind.	150,000	1200 lb., 825° 1" Abs.	Shipped
Ford Motor Co. Detroit, Mich.	110,000	1200 lb., 725° 1" Abs.	In service
New Jersey Power & Light Co. Holland, N. J.	55,000	1200 lb., 725° 1" Abs.	In service
Pacific Gas & Electric Co. (2) San Francisco, Cal.	55,000	1250 lb., 750° 1" Abs.	In service
American Gas & Electric Co. Deepwater, N. J.	53,000	1200 lb., 725° 1" Abs.	In service
American Electric Power Co. Deepwater, N. J.	53,000	1200 lb., 725° 1" Abs.	In service
Jersey Central Power & Light Co. (2) South Amboy, N. J.	25,000	1250 lb., 750° 1" Abs.	In service
American Gas & Electric Co. and American Electric Power Co. Deepwater, N. J.	12,500	1200 lb., 725° 400 lb. B.P.	In service
Edison Electric Illuminating Co. Boston, Mass.	12,500	1200 lb., 700° 375 lb. B.P.	In service
Houston Light & Power Co. Houston, Tex.	12,000	1250 lb., 750° 360 lb. B.P.	In service
Edison Electric Illuminating Co. Boston, Mass.	10,000	1200 lb., 700° 375 lb. B.P.	In service
Milwaukee Elec. Railway & Light Co. (3) Milwaukee, Wis. (1)	7,700	1200 lb., 750° 315 lb. B.P.	In service
Edison Electric Illuminating Co. Boston, Mass.	3,000	1200 lb., 700° 360 lb. B.P.	In service
Firestone Tire & Rubber Co. Akron, Ohio	10,000	1250 lb., 750° 235 lb. B.P.	On order
Ford Motor Co. Detroit, Mich.	110,000	1200 lb., 900° 1" Abs.	On order
Ford Motor Co. Detroit, Mich.	15,000	1200 lb., 900° 250 lb. B.P.	On order

FIG. 2—1200-Lb. Turbine-Generators Manufactured by the General Electric Company

plant—the 110,000 Kw. steeple compound condensing unit for the Rouge plant of the Ford Motor Co., and the 10,000 Kw. non-condensing super-imposed unit at the Firestone Tire and Rubber Co. Many other

FIG. 3—Increased Useful Energy from 1200 Lbs. to 200 Lbs.

condensing and non-condensing turbines have been installed in industrial plants having initial pressures of 400 to 600 pounds and temperatures from 550° to 725° used, mainly, to furnish process steam at some lower pressure. The heavy use of low pressure steam in industrial plants makes an ideal application for the high-pressure non-condensing turbine. The chemical, paper, rubber, textile and steel industries seem to present some possibilities for the profitable adoption of this tool.

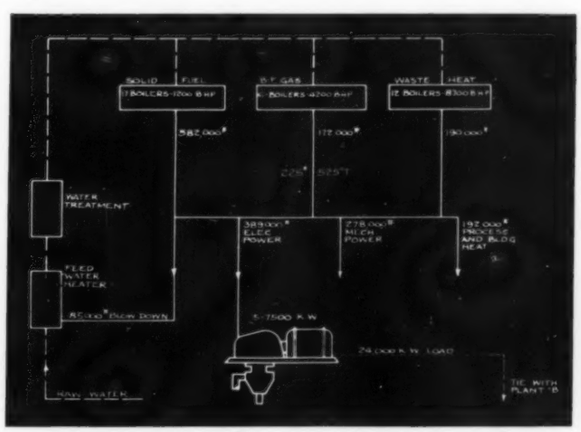


FIG. 4—Plant A. Present Conditions.

The usual steel mill conditions presented indicate existing boiler and turbine generator plants operating at steam pressures between 150 and 275 lbs., with the general average of the less modern plants at about 200 lbs. Illustrated on a heat energy diagram (Fig. 3), the proportion of used heat from 1200-lbs. to 200-lbs. shows that about half as much energy as can be used between 200-lbs. and 2-inch Hg. absolute backpressure, lies between 200 and 1200 pounds. Therefore, for the same weight of steam, 55% more electrical energy can be found by generating steam at 1200-lbs. and passing it through a non-condensing turbine than can be generated by the low-pressure condensing turbine. Where low pressure steam is used for other than power purposes, it is preferable to generate between low pressure and condenser that part of the power necessary to hold the pressure constant in the low pressure header, by operating only that amount of speed governed low pressure generator capacity required to absorb peak electrical demands while maintaining constant frequency. In this way, losses to condensing water are reduced to a minimum. The steam turbines of ten years ago, eliminating losses due to use, are still comparatively efficient machines and certainly merit careful consideration before release to the scrap pile, particularly when one or more properly proportioned sizes are still useful for carrying a fraction of the total station load. Beside effecting a major reduction in losses by eliminating a large part of the total heat previously rejected to the condenser, a large salvage can be made in the boiler losses which have gradually increased with time and use. Efficient boilers, today, start off with approximately 10% higher heat recovery than many boilers did ten years ago, while use may account for 10 to 15% decrease in original efficiency. Improvements in auxiliaries, stokers and fuel firing equipment will account for another percent or two, so in all, there is a possibility of recovering 25 to 35% more heat with new equipment than is accomplished in plants of five to ten years age.

In the paper industry, the use of steam for process has a fairly fixed ratio to units of product, and for varieties of product the ratio also is relatively constant throughout the industry. Steel producers apparently do not all think alike as a wide divergence is found in the same class of producers as to the ratios of steam for electric and mechanical power and steam for process.

The foregoing general remarks are substantiated by investigations of actual conditions of which the following four cases are representative. The calculations are rough and do not attempt to bring out all the possibilities. In fact, heat usually recovered in

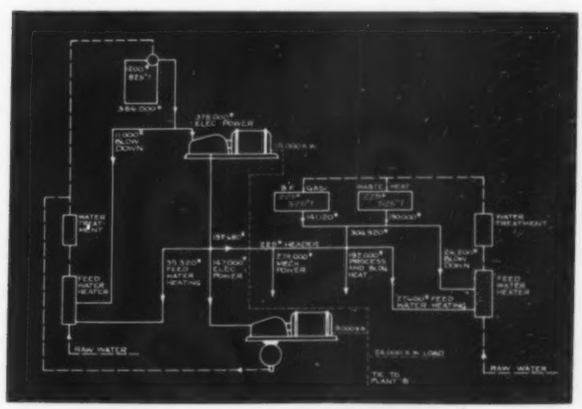


FIG. 5—Plant A with 1200-Lb. Boiler and Non-Condensing Turbine, retaining 225-Lb. waste heat and sufficient gas-fired boilers to absorb peak loads.

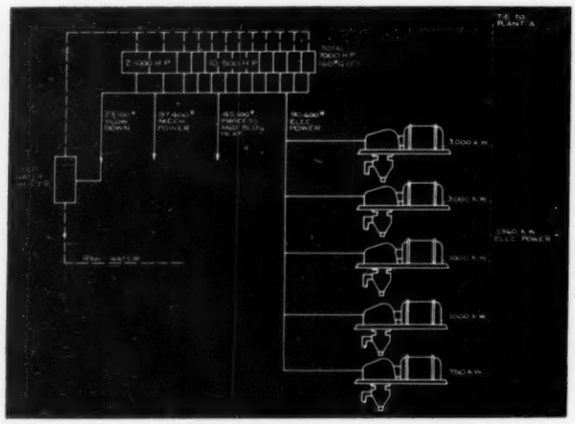


FIG. 6—Plant B. Present Conditions.

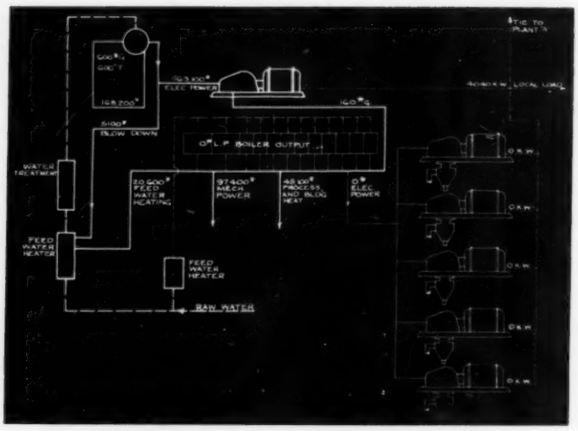


FIG. 7—Plant B. 600-Lb. Boiler and Non-Condensing Turbine, speed controlled by an electric tie with Plant A.

economizers and air preheaters has been neglected for simplicity. The results are, however, sufficiently close to emphasize the main points under consideration. The data are taken from present-day operations of steel and tin mills, the collection and use of which we wish to acknowledge our appreciation. For obvious reasons, the plants are designated only by letter. Fig. 4; Fig. 5.

Plants A and B, under one management, are located a short distance apart and are supplied by independent steam power plants with individual electrical generating equipment connected together by a tie line. Their products are widely divergent as to by-product heat, power and steam requirements. The analyses of these plants are therefore made independently but the conclusions reached make it seem

Steam Distribution		Present	Proposed	% Saving
Mechanical Power	lbs./hr.	278,000	278,000	
Process and Building Heat	"	192,000	192,000	
Electric Power	"	389,000	147,000	
Blow Down	"	85,000	37,200	
Feed Water Heating	"	Incl. above	62,920	
Total		944,000	717,120	
Steam Generated				
At 225 lbs., 525°	lbs./hr.	944,000	331,120	
At 1200 lbs., 825°	"	.....	386,000	
Total		944,000	717,120	24.1
Electric Power				
L.P.	K.W.	24,000	15,000	
H.P.	"	.....	9,000	
Total		24,000	24,000	
Fuel Used				
Coal	$/T.	1.80	1.80	
Coal Heat Value	BTU/lb.	12,500	12,500	
Blast Furnace Gas	BTU/Cu. Ft.	90	90	
Coke Breeze	BTU/lb.	11,000	11,000	
Waste Heat		Yes	Yes	
Fuel Cost (in terms of coal)	$/Yr.	1,010,000	680,000	32.6
Water Treatment	$/Yr.	20,800	17,500	15.9
Total Fuel and Water Treatment	$/Yr.	1,030,800	697,500	32.3
BTU Fuel per Lb. Total Steam		1,700	1,530	10.
BTU Fuel per KWH Gen.		28,800	16,360	43.2

FIG. 8—Plant A. Summary of Operations—Present and Proposed

Steam Distribution		Present	Proposed	% Saving
Mechanical Power	lbs./hr.	97,400	97,400	
Process and Building Heat	"	45,100	45,100	
Electric Power	"	90,400	.....	
Blow Down	"	23,100	5,100	
Feed Water Heating	"	Incl. above	20,600	
Total		256,000	168,200	
Steam Generated				
At 160 lbs., 0° Superheat	lbs./hr.	256,000	.....	
At 600 lbs., 600° T.T.	"	.....	168,200	
Total		256,000	168,200	34.3
Electric Power				
L.P.	K.W.	3,860	.....	
H.P.	"	.....	4,040	
Total		3,860	4,040	
Fuel Used				
Coal	$/T.	1.80	1.80	
Coal Heat Value	BTU/lb.	12,500	12,500	
Blast Furnace Gas	BTU/Cu. Ft.	.....	.....	
Coke Breeze	BTU/lb.	.....	.....	
Waste Heat		.....	.....	
Fuel Cost (in terms of coal)	$/Yr.	278,000	145,000	48.
Water Treatment	$/Yr.	4,780	6,520	36.4
Total Fuel and Water Treatment	$/Yr.	282,780	130,260	46.
BTU Fuel per Lb. Total Steam		1,725	1,365	20.9
BTU Fuel per KWH Gen.		44,400	5,320	88.0

FIG. 9—Plant B. Summary of Operations—Present and Proposed

advisable to retain the electrical tie in order that the condensing turbines in Plant B may be shut down, and dependence for frequency regulation placed on

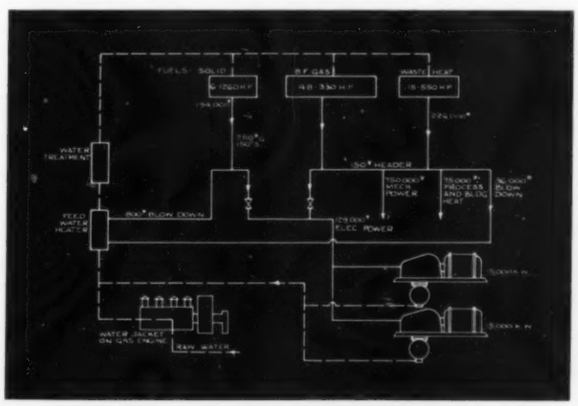


FIG. 10—Plant C. Present Conditions.

those in Plant A. In general, it will be found economical to generate the new, highly efficient plant at a load near to the point of best economy and let the peaks, which constitute a relatively small portion of the total output, be taken on the less efficient, older plant, so entailing a relatively small loss due to not replacing that part of the old low pressure equipment required with a modern plant. By-product blast furnace gas, being generated in quantities bearing some proportional relation to steam requirements,

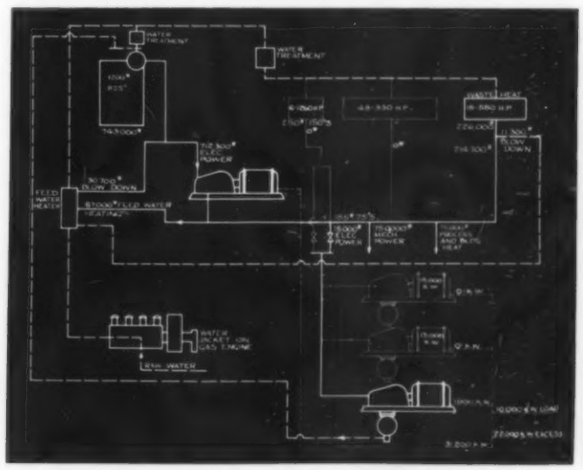


FIG. 11—Plant C. Using 1200-Lb. Boilers and Non-Condensing Turbine with present waste heat boilers supplying 155-Lb. steam.

		Present	Proposed	% Saving
Steam Distribution				
Mechanical Power	lbs./hr.	750,000	750,000	
Process and Building Heat	"	75,000	75,000	
Electric Power	"	129,000	15,000	
Blow Down	"	44,000	42,000	
Feed Water Heating	"	Incl. above	87,000	
Total		998,000	969,000	2.91
Steam Generated				
At 250 lbs., 150° Superheat	lbs./hr.	194,000	.....	
At 155 lbs., 0° Superheat	"	804,000	226,000	
At 1200 lbs., 825° T.T.	"	.....	743,000	
Total		998,000	969,000	
Electric Power				
L.P.	K.W.	10,000	31,200	
H.P.	"	.....	1,000	
Total		10,000	32,200	222
Fuel Used				
Coal	$/T.	2.50	2.50	
Coal Heat Value	BTU/lb.	12,200	12,200	
Blast Furnace Gas	BTU/Cu. Ft.	90	.....	
Coke Breeze	BTU/lb.	11,000	.....	
Waste Heat		Yes	Yes	
Fuel Cost (in terms of coal)	$/Yr.	1,530,000	1,330,000	0.65
Water Treatment	$/Yr.	30,600	35,430	7.12
Total Fuel and Water Treatment	$/Yr.	1,560,600	1,390,030	0.50
BTU Fuel per Lb. Total Steam		1,718	1,527	11.1
BTU Fuel per KWH Gen.		22,892	9,191	59.8

FIG. 12—Plant C. Summary of Operations—Present and Proposed

has been selected as the most advantageous fuel to use for peak loads.

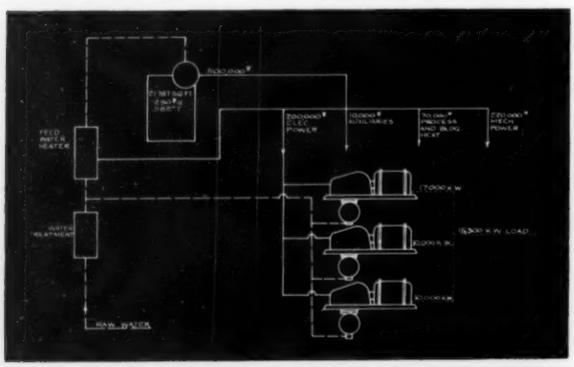


FIG. 13—Plant D. Present Conditions.

For the purpose of this discussion, no attempt has been made to investigate the possibility of using high pressure boilers to recover waste heat. If practicable, this source of heat, being one of the most economical, should be used first as there is no other market for it. Coke breeze and blast furnace gas come second in choice as there are some other plant uses for these fuels but have not much market outside the plant of generation. Coal, obtained outside the boundaries of the plant, has a recoverable mar-

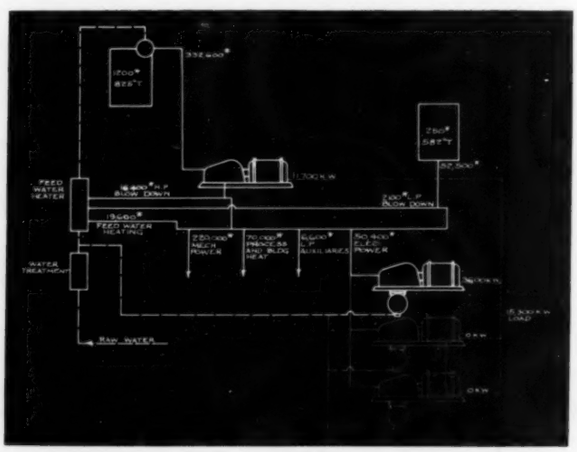


FIG. 14—Plant D. Proposed addition of 1200-Lb. Boilers and Non-Condensing Turbine, retaining sufficient 250-Lb. boiler and turbine capacity to carry peak loads.

		Present	Proposed	% Saving
Steam Distribution				
Mechanical Power	lbs./hr.	220,000	220,000	
Process and Building Heat	"	70,000	70,000	
Auxiliaries	"	10,000	6,600	
Electric Power	"	200,000	50,400	
Blow Down	"	Incl. above	18,500	
Feed Water Heating	"	Incl. above	19,600	
Total		500,000	385,100	23.0
Steam Generated				
At 250 lbs., 582° T.T.	lbs./hr.	500,000	52,500	
At 1200 lbs., 825° T.T.	"	.....	332,600	
Total		500,000	385,100	
Electric Power				
L.P.	K.W.	15,300	3,600	
H.P.	"	.....	11,700	
Total		15,300	15,300	
Fuel Used				
Coal	$/T.	2.00	2.00	
Coal Heat Value	BTU/lb.	12,935	12,935	
Fuel Cost (in terms of coal)	$/Yr.	487,000	386,000	20.8
Water Treatment	$/Yr.	21,700	29,600	36.4
Total Fuel and Water Treatment	$/Yr.	508,700	415,600	18.35
BTU Fuel per Lb. Total Steam		1,440	1,488	3.3
BTU Fuel per KWH Gen.		18,950	8,190	57.0

FIG. 15—Plant D. Summary of Operations—Present and Proposed

ket and so sets a value on by-product fuels based on heat per dollar selling price.

These general remarks apply with equal force to the other plants under consideration. Fig. 6; Fig. 7.

The data given in Figs. 4, 5, 6 and 7 show all the essentials of existing conditions and proposed modifications. Fig. 8 and Fig. 9 summarize some of the results which may be expected. Leaving the peaks to be generated in Plant A by the low-pressure gas-fired boilers and allowing the low-pressure waste heat boilers to remain, results in a fairly large percentage of the electrical load being carried by the condensing machine. As an alternative method, transferring the generation of the 331,120 lbs. per hour from the low-pressure boilers to additional new 1200-lb. boilers will yield the same low-pressure steam and deliver about 6850 Kw. excess power over and above present plant electrical requirements, while plant frequency could be held constant by a relatively small amount of power generated by a condensing machine.

The economies which might be secured by the adoption of high-pressure non-condensing turbines, without changing the waste heat boilers from low to high pressure, are, for Plant A, in themselves worthy of attention. Reduction of steam generated by 24% is reflected in the fuel cost, as well as the benefits of higher plant efficiency, all of which is expected to show a saving in fuel and water treatment costs of some 32%.

Plant B burns coal entirely and, since its electrical tie to Plant A allows it to eliminate condensing

	POUNDS OF STEAM PER HOUR			PERCENT	
Plant.	Total Steam	Mech. Pwr.	Elec. Pwr.	Mech. Pwr.	Elec. Pwr.
A	667,000	278,000	389,000	41.0	59.0
B	187,800	97,400	90,400	53.4	46.6
C	879,000	750,000	129,000	85.3	14.7
D	420,000	220,000	200,000	52.4	47.6

FIG. 16—Relative Amounts of Steam for Mechanical and Electrical Power

machines, a still greater proportional saving can be shown. Because this plant is not large, and in order to arrive at a virtual steam-power balance, operating conditions of 600-lb., 600° were selected. The savings to be expected in Plant B are a 34% reduction in steam generated, 46% saving in fuel and water treatment costs, and an 88% reduction in heat per KWH of power generated Fig. 10; Fig. 11.

Waste heat boilers are again found in Plant C and, for reasons given above, are supposed to re-

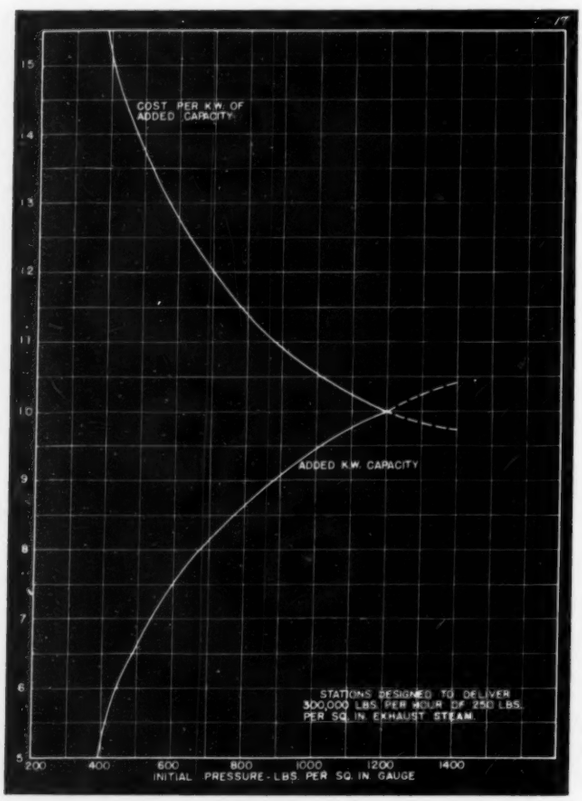


FIG. 17—Non-Condensing Steam Turbine Station Costs and Useful Energy at Various Pressures.

main low-pressure boilers. The analysis, here, has been made to show how much power could be made if all remaining steam required were generated at 1200-lb. About 40% of the 750,000 lbs. of steam to mechanical power goes to mill drives which might be driven electrically. These are a possible outlet for excess electrical power. Some balance between steam and by-product electrical power should be found so as to obtain maximum benefit from possible economies. Fig. 12.

This plant shows only a relatively small (3%) reduction in steam generated and practically no reduction in cost of fuel and water treatment by going to high pressure, as the emphasis is placed on maximum possible electrical power which yields an excess over plant load of 222%. The possible savings, when power and steam balance, are indicated, however, by a 60% saving in the heat required to generate a KWH of power under unbalanced conditions. Fig 13; Fig. 14; Fig. 15.

Plant D is now a fairly efficient plant as its heat generating equipment now operates at about 78% and its turbine-generators at about 68%. The proportions of steam to mechanical power, process and building heat are, like the other plants, relatively a large part of the total—60%. While the amount of steam generated can be appreciably reduced (23%) and a material improvement made in the fuel burned per KWH of electrical energy (57%), the low cost of fuel ($2.00 per ton of 12,935 BTU per lb. coal) does not yield as high a fuel saving (18.3%) as has been indicated in the other plants investigated. It is sufficient, however, to suggest that the present boiler efficiency be watched and, when it becomes sufficiently low, plans for replacement take into consideration the super-imposed plant idea. Fig. 16.

From inspection of the individual plant operating conditions, it is obvious that a super-imposed power plant will have an opportunity to make a favorable showing. The large portions of steam for mechanical power, process and building heat, required at relatively low pressures, give the most favorable opportunity for the non-condensing turbine. In the case of Plant B, a balance was obtained, so that at the high pressure selected the steam required met the electrical demands. In Plant C it was shown that there is a possible 222% increase in electric power over plant requirements, due to the large amount of steam to mechanical power.

Breaking down the outlets for mechanical power steam, it is found that they classify themselves into:

Practical and economical electric drive.
Impractical and uneconomical electric drive.
Practical but uneconomical electric drive under present conditions.

With power costs reduced by more lower cost means of producing electricity, some present applications of steam for mechanical uses will shift when electricity is suggested from the economical side to the uneconomical side of the ledger.

Pure boiler water is the paramount consideration of the high temperature and pressure plant. From a chemical standpoint, it seems possible to reduce the impurities which cause tube failure and the solids which cause bucket and nozzle wear. The equipment necessary to introduce the reagents is not excessively expensive and the cost of water treatment is not a large amount. Most high-pressure plants now in operation and from which relatively large amounts of steam are taken for other uses have adopted evaporators to give a constant source of acceptable feed water. This added feature does not necessarily make the high-pressure plant prohibitive, but the losses and cost of evaporating large amounts of raw water tend to reduce the profits realizable in the system using water treatment.

To summarize the results of this investigation, it is first of all apparent that, for various reasons, relatively large proportions of power are obtained direct from steam; some smaller amounts of steam go to process and building heat. Changed financial and production conditions may eliminate some of the present uses of steam for mechanical power, but it will be advisable to closely inspect the advantages of generating added amounts of electrical power from the available heat drop between higher steam pressures and those lower pressures in general use today in order to secure as nearly as possible a balance of electric power to steam required for mill uses at the lower pressures. The tendency is to use more electrical power per unit of product justi-

fied by economy or higher return from the product which depends on electricity for its quality. There is a considerable background of experience with high-pressure plants from which to draw in order that maximum reliability may be obtained. Boiler water impurities should be reduced in order that maintenance costs be low and reliability given at a maximum. Failing justification for mere chemical treatment of the feed water, resort can be had, at some moderate increase to operating costs, to evaporators which have been successfully used in existing plants. Fig. 17

Discussion

Discussion Presented by

E. W. Trexler, Superintendent of Steam & Combustion, Bethlehem Steel Company, Johnstown, Pa.
G. T. Hollett, Steam Engineer, Illinois Steel Company, South Chicago, Ill.
A. G. Darling, Industrial Engineer, General Electric Company, Schenectady, N. Y.
J. L. Miller, Asst. Chief Engineer, Carnegie Steel Company, Youngstown, Ohio.
W. T. McCullough, Jr., District Manager, The Babcock & Wilcox Co., Pittsburgh, Pa.
E. W. Wagenseil, Sales Manager, Hall Laboratories, Inc., Pittsburgh, Pa.
J. H. Strassburger, Steam Engineer, Weirton Steel Company, Weirton, W. Va.

E. W. Trexler: Mr. Darling has given us a fine paper. He has given us food for thought, especially those of us in the steel plants. We know that our plants are being motorized more and more every day, and our boilers are becoming older and less efficient. In some of our plants the water is scarce. It looks as if answers to some of these problems have been suggested by Mr. Darling.

In opening this discussion, I would like to ask Mr. Hollett if he will present his views on this paper.

G. T. Hollett: I would like to ask a few questions rather than tell you about what we have done. I would like to ask Mr. Darling where he would recommend changing the pressure from 600 pounds to 1200 pounds. We have done considerable studying of this subject and 600 pounds seems to be as high as we can go in pressure to show the maximum return on our investment. When you get above 600 pounds it involves a re-heat cycle. The feed water with the 1200 pound pressure is an important item, particularly where you have a large percentage of your steam going for other uses.

A. G. Darling: I would like to be able to give a definite answer to your question but would require an analysis of your plant in order to do so. The argument of the paper does not contain the statement that every plant should adopt 1200 pound turbines. It does, however, by analysis of several plants, show what could be done by using 1200-lbs. as an example. I quite agree that some plants would never show a saving by adopting this pressure. The cost of satisfactory feed water must be taken into consideration, whether evaporation or treatment is used for either 600 or 1200-lbs. Knowing so little of the actual circumstances which are involved in your plant, I do not feel competent to advise you which pressure should be used.

J. L. Miller: In the matter of superimposed power plants for steel mills, Mr. Hollett of the Illinois steel Company and I have made studies of this subject during the past three or four years. I think Mr. Darling's analysis and method of going about it is very interesting and very logical. But I do not think, in studying an industrial plant, a steel mill in particular, that you can start with the steam alone. We have a certain amount of blast furnace gas and a certain amount of waste heat that must be utilized. We must go back to the total heat in the fuel for power purposes and we cannot start with the steam. For example, your percentage figures there are really misleading as to the true conditions which exist in the steam plant. I didn't want to let that point go by, because we are interested in fuel balance.

A. G. Darling: I have yet to find the steel mill operator who will set a figure on the value of his by-product fuel and use that figure under all circumstances. This is perhaps justifiable for, if the fuel is for sale, it is worth its heat value as compared with the heat value of competitive fules; but if it is to be used in the plant of its manufacture, it may cost that plant an appreciable sum to dispose of the by-product in some other way. The savings illustrated are based on the comparative heat values of the fuels.

W. T. McCoullough, Jr.: Boilers and superheaters for 1200 pounds pressure and 850 to 900 degrees total temperature are available at reasonable cost. An important feature of any contemplated 1200 pound pressure installation, or for any other high pressure, is the matter of water treatment. I know of two plants where the percentage of feed water make-up is approximately 100%. One of these plants operates at a pressure of 800 lbs. and the other at 650 lbs. Both plants have chemically treated feed water and with satisfactory results. In one of these plants it is their regular practice to keep the high pressure boiler on the line continuously for six months without shutting down.

E. W. Wagenseil: So far as the matter of pressure is concerned, it makes no difference whether the boilers operate at 600 pounds, 800 pounds, or 1200 pounds pressure, they can be kept absolutely clean without the necessity of resorting to evaporated makeup. In other words, it is merely a matter of proper boiler water chemistry.

We have many boilers operating at high pressures, with high percentages of makeup from softeners, which are maintained in perfect condition and are kept on the line for long periods of time without any scale formation whatsoever. The maintenance of the proper amount of phosphate (and proper alkalinity) in the boiler water as secondary conditioning following the softener will absolutely inhibit scale formation regardless of pressure.

J. H. Strassburger: One of the examples given by Mr. Darling was that power was generated on a 1200-pound boiler plant, the turbine exhausting process steam at 250 pounds, and that power was also generated on 250 pounds condensing generators. In

order to obtain the greatest economy, is it correct that the 1200-pound turbine should be loaded as a base load machine and the variations of load carried on the 200-pound pressure units? If this is the case, Mr. Darling has shown that all of the coal-fired boilers at 250 pounds pressure are out of service and the only fuel available would be blast furnace gas and waste heat, which fuels are not conducive to handling variations in power load.

A. G. Darling: I agree that it would be necessary to operate coal fired units on the 200-pound pressure line, in order to carry the variation of power load on the 200-lb. machines.

In Memoriam

John Kelly has passed on and our Association of Iron & Steel Electrical Engineers is like a watch without a main spring.

To many, John Kelly was the personification of the Association, call him an employee if you will; nevertheless, those of us, who have served on the Board of Directors, and more especially those few who have been honored with the Presidency of our Association, know only too well that the truth of the matter was that John Kelly was the very life and soul of the Association. He planned and accomplished always with the objective of advancing the prestige of our organization, bettering our magazine and making our Exposition more worthwhile to those of us who attended to see and study; as well as, those who displayed their products for our mutual benefit.

Again I say that only those of us who, by virtue of our official connection with the Association were privileged to come into intimate contact with our genial and efficient Executive, can fully appreciate his worth and thereby properly evaluate the loss to our Association.

John has gone, but the A. I. & S. E. E. must go on. It has earned the right to occupy an enviable place in the Steel Industry, and we who remain are obligated both to the Industry we serve and to the memory of one who worked so tirelessly for our interest to keep the A. I. & S. E. E. advancing to new and greater future activities in an effort to realize the dreams of our late Managing Director.

If I may interject my personal feelings into this statement, I think I can express the feelings of many when I say that I have experienced a great personal loss, and it will be hard indeed to think of the A. I. & S. E. E. without finding the familiar personality of John Kelly appearing in our mind's eye as the ever dominating and directing force behind our Association activities.

A. J. STANDING, Past President
of the A. I. & S. E. E., and
Electrical Superintendent,
Bethlehem Steel Company,
Bethlehem, Pa.

Flames centering steel rounds with the flame machining blowpipe.

Oxy-Acetylene Welding and Cutting In Metal Working

By W. S. WALKER,
The Linde Air Products Company, Cleveland, Ohio.

Paper presented at the A. I. & S. E. E. Annual Convention held in Cleveland, Ohio, September 18, 19 and 20, 1934.

In view of the widespread, almost universal use of the oxy-acetylene process in every branch of metal working, it is difficult to realize that its entire commercial development has taken place within the last 30 years.

Some of the first applications for this revolutionary process were found in the steel mill and foundry —for tapping furnaces, cutting up spills, and billets and removing risers from castings. Other early applications were in the manufacture of iron and steel products, where oxy-acetylene welding was employed in the fabrication of tanks, piping and sheet metal articles; and in the repair and salvaging of machinery and other equipment where the oxy-acetylene process was utilized to an even wider extent. Gradually, welding methods and materials were perfected for the non-ferrous metals such as copper, aluminum, nickel and their respective alloys, and the use of oxy-acetylene welding became widespread. Today, practically all metals can be successfully welded by this process, as a result of constant research on welding techniques, welding rods and fluxes, and weldable metals.

Developments in this method of cutting occurred at a more gradual pace until several years ago when some truly remarkable advancements were made. Appropriately enough, the most noteworthy of these cutting developments took place in steel manufacturing where many of the early applications of oxy-acetylene cutting had originated.

Many uses of this process in metal working are too well known to be recounted. Several well known applications, however, have been given new significance by recent investigations; and several entirely new, outstanding developments in oxy-acetylene welding and cutting which have been put into extensive use in the last few years, give definite promise of widely extending utility. These advancements will interest particularly all who are concerned with the manufacture of iron and steel, the fabrication of metal products, and the maintenance of mechanical equipment.

Lindewelding

In the field of oxy-acetyene welding, one of the most notable developments in recent years is the Lindeweld method for fusion welding steel. Ox-welding procedures in the construction of overland pipe lines have been completely altered by the new

welding method, which has thus far been employed for over 4,000 miles of high pressure oil and gas lines ranging in diameter from 4 in. to 26 in. In fact it is now the standard method for oxy-acetylene welding pipe lines.

An idea of the remarkable advancement in welding methods this represents can be gained from construction records. Whereas 15 to 20 six-inch welds a day was formerly considered good production for a pipe line welder, 50 to 60 welds a day per welder is regularly obtained on Lindewelded lines, with production of 70 to 80 welds per day possible with light wall pipe and good welding conditions. Proportionate increases have been secured with pipe of other diameters.

A huge cast iron mill rod frame repaired by oxwelding with bronze rod. Breaks were completely through both legs of the frame.

This method makes use of an excess acetylene flame, a special welding rod, and a carefully worked out welding technique in securing records such as those just mentioned. This combination makes for welds of high quality as well—amply strong for the high strength steel pipe so widely used at present. Saving in rod and gases amounts to from 25 to 50 per cent.

Since it is possible to make overhead and horizontal welds by Lindewelding with practically the same facility as rotation welds, the new method is equally adaptable to welding industrial and building piping.

Aircraft

Besides the quite natural applications of Lindewelding to plate and tank work as a result of the remarkable success in pipe welding, the new method has also been extended to the welding of tubular joints in aircraft. Joints in unusually thin tubing, which previously had not been satisfactorily welded by any other means, have been successfully made by this welding procedure. Joints of higher efficiency are obtained, particularly after heat-treatment and it is expected that this process will be used increasingly in aircraft welding.

Extension of aircraft construction methods to other branches of the transportation industry is seen in the announcement of a light weigh, high speed rail car just manufactured in Chicago with framework of both coach and trucks fabricated from aircraft tubing with oxwelded joints. This car is no doubt the forerunner of many other applications to be made of welded tubular construction where lightness combined with great strength is necessary.

Bronze-Welding

The utility of bronze-welding—always a popular welding method—has been greatly increased by the perfection of a new bronze-welding rod which makes possible much higher strengths, greater hardness and easier application than could be secured with rods previously obtainable. Strengths between 56,000 and 60,000 lb. per sq. in. with ductility in excess of 30 per cent are quite readily obtained in welds joining steel. These results approach those secured with high test steel welding rod and are much better than those obtainable with low carbon steel welding rod where tensile strength in the weld rarely exceeds 50,000 lb. per sq. in. The hardness of the weld metal, of importance where bronze-welding is used for building-up wearing surfaces, is exceptionally high for bronze rod, being 96 Brinell. Thus, bronze-welding can be employed with confidence for many new applications and its merits consideration as the most widely useful method of welding known to industry.

To the welder, this improved bronze-welding rod has the advantage of being low-fuming, increasing his comfort to the extent that bronze-welding is done with the same ease as welding with steel or iron rods.

Applications of bronze-welding are well known but some of the more important will be mentioned briefly. Bronze-welding is regularly employed in the repair of fractured cast iron machinery frames and bases, some of the largest frames in use having been successfully reclaimed by this method. Automobile cylinder blocks, locomotive steam cylinders and boiler sections are other examples of cast iron repair. Cast iron pipe joints are bronze-welded in the foundry and field to secure strong, leakproof connections. Miscellaneous steel, cast iron and malleable iron parts are regularly repaired at small expense by bronze-welding.

Considerable sheet metal welding in the fabrication of containers is being done by bronze-welding, especially where the sheet is galvanized. Galvanized pipe joints are frequently bronze-welded in preference to being fusion welded since less of the galvanizing is affected. Copper, nickel and many of their alloys, whether in the form of castings, plates, or shapes, are often bronze-welded to give results equal or superior to fusion welding.

Increasing popularity of brass pipe in the larger diameters has led to research on joint design for bronze-welding disclosing that the simple vee type joint—standard for steel pipe—gives an entirely satisfactory connection of high efficiency. The bronze-welding is accomplished in all positions with practically the same facility as welding steel pipe.

Bronze-Surfacing

In the building-up of worn surfaces on machinery parts, bronze-surfacing—the term for bronze-welding

when used for overlays—is a method of outstanding success, particularly when the built-up surfaces are to be machined to fit. In the case of parts such as cast iron pistons, surfaces rebuilt with bronze frequently give longer service than the original cast iron because of the excellent wearing properties of bronze metal against lubricated cast iron cylinder walls. Although bronze-surfacing of pistons has been practiced in certain plants for many years, there has been greatly increased interest in such work since the improved bronze welding rod has become available. The initial cost of piston reclamation by bronze-surfacing is usually only one-third to one-quarter the expense of installing new pistons, and in many cases an appreciable saving in time is made. Pistons can be bronze-surfaced and machined to fit again and again, extending their life almost indefinitely.

Other parts regularly bronze-surfaced are sliding valves and seal rings in pumps, rocker arm rollers, lever bearings, gear teeth, shafts of all kinds, spindles, yokes, pins and clevises. The worn areas are built up oversize with bronze and are then machined to the proper size or fit. Many auto, truck and bus parts made of cast or forged steel are regularly reclaimed in this manner, saving immense sums in replacement parts to large fleet owners who have established the practice.

Copper Alloys

A problem associated with bronze-welding has been the fusion welding of various brasses and bronzes containing sufficient tin and lead or both to interfere seriously with ordinary welding methods. Laboratory investigation of this trouble showed that properly adjusted oxidizing flames would make satisfactory welding possible, giving weld metal deposits practically free from oxides and objectionable blowholes. The silicon bronze welding rod further aids in improving weld quality. Welding techniques perfected through use of properly adjusted oxidizing flame have thus made possible the welding of many types of brass and bronze formerly thought to be unweldable. This has been of particular advantage in the case of extruded brass used for architectural purposes.

Corrosion-Resisting Iron and Steel

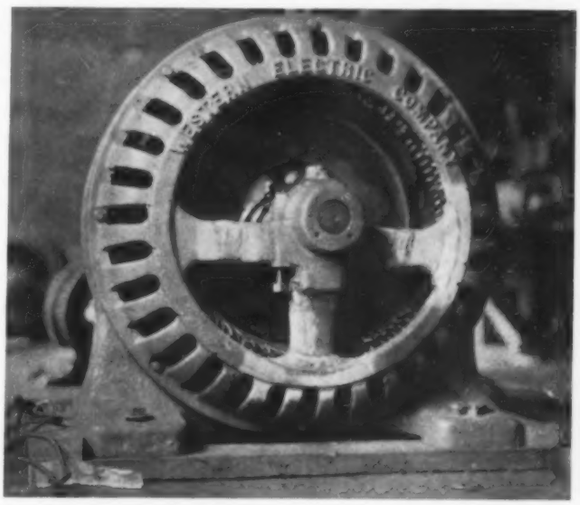
The welding of corrosion-resisting irons and steels has been given increased attention in the last year due to growth in the use of these metals for brewery equipment and metal furniture. By following correct practices recently published, these irons and steels can be successfully oxy-acetylene welded in practically all cases. Investigation directed toward improving the weldability of these metals has shown that the addition of titanium to the 18-8 chrome-nickel steels gives marked improvement in the quality of the deposited metal, greatly increasing its resistance to corrosion. Carbon should be limited to 0.07 per cent, with the titanium content at least four times that of the carbon but not over 0.4 per cent. A special flux should be used in most cases to facilitate the welding operation.

Nickel and Aluminum

There have been no recent developments of any importance in the oxwelding of two other important metals; nickel, aluminum or any of their respective alloys, which are widely used for welded containers and other products requiring welded joints. The aluminum rod containing silicon, brought out several years ago, is being widely utilized for welding cast aluminum where its property of slow solidification from the molten condition aids in absorbing contraction stresses which normally makes very careful pre-heating and cooling after welding necessary.

Hard-Facing

The use of hard-facing to combat severe wear of metal parts is growing in popularity, especially in the steel industry where maintenance costs must be kept low.



The end bearing support in the cast iron frame of this electric motor was broken in five places during an accident and repaired by means of bronze-welding.

The process of hard-facing is defined as the application of a thin coating of a hard, wear-resistant alloy to the wearing surfaces of any type of metal parts.

In general there are four groups of hard-facing materials—(1) Low alloy steels (2) iron base alloys containing considerable percentages of such elements as chromium, tungsten, manganese, silicon and sometimes cobalt and nickel, (3) the non-ferrous cobalt-chromium-tungsten alloys and (4) the so-called diamond substitutes which are essentially tungsten carbide.

The first group of materials is used for general building-up purposes and for conditions of mild abrasive wear. The second group is used for hard-facing applications involving considerable shock and impact and where a strong, tough surfacing is desired. Applications of the second group include gyratory crusher mantles, crusher jaws, dipper teeth, etc. The non-ferrous alloys of the third group are used under conditions of severe abrasive wear and especially where wear takes place at elevated temperatures. Hard-facing materials of this group have the distinct advantage of retaining their high initial hardness even at red-heat temperatures, a most important factor in wear-resistance. The fourth group comprises

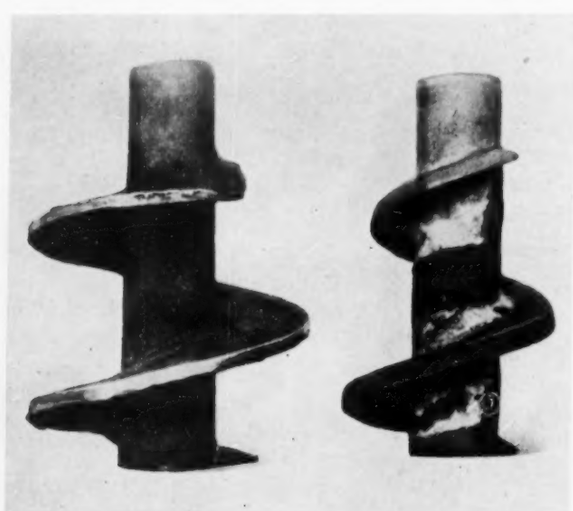
the tungsten carbides, which are used in the form of small pea-shaped nuggets called inserts, or in uniformly crushed particles which are held in a binder of steel welding rod. These diamond substitutes find their principal use for facing oil well drilling tools.

Of the various hard-facing materials, the third group, represented by Haynes- Stellite, an alloy of cobalt, chromium and tungsten is of primary importance to the steel industry. When cold, this non-ferrous alloy is almost as hard as hardened steel and has the unique property of retaining its original hardness at the high surface temperatures developed by friction—and even at a red-heat. This important property of "red-hardness" accounts for the good results obtained by this hard-facing material.

Hard-facing by the oxy-acetylene process is a welding operation similar to bronze-welding or tinning. The base metal is brought to a sweating heat and the rod melted in the flame of the blowpipe and deposited on the wearing surfaces. In this way it is possible to apply the alloy without intermingling with the base metal.

A few typical hard-facing applications in the steel industry will give an idea of the tremendous possibilities and scope of the process. Hard-facing gag press hammers for straightening structural steel is an outstanding application in this field, hard-faced hammers outlasting plain steel hammers 10 to 1. Diagonal rolls, used in structural mills for taking up the stretch in steel when it is being rolled show an increase in life of at least four times when hard-faced. Side guides in rail mills, which are subjected to severe abrasion when in contact with the top surface or ball part of the rail, last several months when hard-faced as compared to an average of one week for plain steel castings. The only part of the 52-in. mill guide that usually requires hard-facing is a section of the end coming in contact with the roll. These guides last three or four times longer when hard-faced.

Electric rotary mud guns used to close the tap hole in blast furnaces are subjected to extreme heat and abrasion and last four to five times longer when protected with wear-resistant alloy. The auger used for drilling out solidified mud is also a typical hard-facing application, hard-faced augers drilling six times as many holes as hardended steel augers without resharpening. The life of pug mill paddles for pugging flue dust in sintering plants is increased three times or more by the application of a ⅛-in. layer of hard-facing alloy to the wearing edges. Water cooled pokers when hard-faced have not required replacement after two years' service as compared with a life of only three months for ordinary steel pokers. Hard-facing increases the life of coke pusher shoes three or four times.



On the left is a hard faced electric mud gun screw after four months' service, on the right an ordinary screw after one month's service.

A recent hard-facing development of importance to power plant engineers is the application of the cobalt-chromium-tungsten alloy to the seats and disks of valves used for high-pressure, high-temperature steam service. This non-ferrous alloy is resistant to abrasion, corrosion, wire-drawing, galling and scoring and lasts six to ten times longer than usual materials.

These applications only give a brief idea of the scope of the hard-facing process, there being literally scores of wearing parts in the steel industry which are successfully and economically hard-faced for longer life.

Oxy-Acetylene Cutting

Oxy-acetylene cutting, one of the wonders of the age to those old enough to remember when the heavier masses of steel could be cut only at the expense of great effort, has given birth in the last few years to a new division of the cutting process, involving not the severing of steel but the rapid removal of surface stock. This new division, known as flame machining in contrast to flame cutting, has already become a wonder of the present day. It has excited wide interest, and in its original application in industry—that of removing seams and other defects from billets in the manufacture of steel—it has become a standard practice in practically every steel plant in this country.

Before proceeding with a more detailed discussion of this new division of oxy-acetylene cutting, however, several advances in flame cutting will be mentioned. It has been demonstrated by tests recently that a high degree of precision is possible with flame cutting under favorable operating conditions, especially with respect to the squareness of the cut edge. Longitudinally, the degree of precision depends of course upon the trueness of the cutting machine itself. Under precision machine cutting practices, the tolerances for squareness of cut range from 0.003 in. for plate 1 in. thick to 0.0312 in. for plate 6 in. thick. In many cases, these results equal to if not superior to those obtainable with planing or sawing by machine tools.

Publicity has recently been given to a special technique which was developed for cutting risers from 18-8 chrome--nickel steel castings. It had been practically impossible to do this with ordinary cutting practices and this represents an advance of considerable importance to those who use this oxidation resisting steel in the form of castings.

One of the important applications for machine flame cutting which is growing at a tremendous rate is in the fabrication of machine frames and bases from rolled steel. An entirely new industry has

grown up, so great has been the response to this method of construction. Some of the advantages of assemblies fabricated by welding together flame-cut parts are:

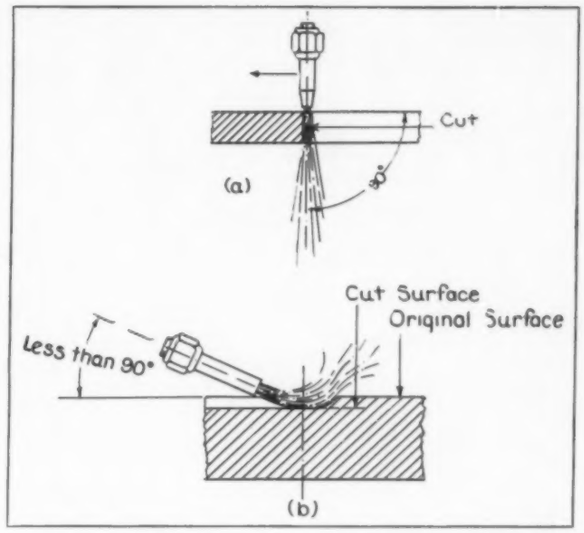
1. The uniformity and excellent properties of rolled steel are present in the finished product.
2. More logical design is possible since metal need be placed only where it is needed.
3. Different metals such as carbon steel, alloy steel and non-ferrous metals or steel castings can be welded together in the same assembly.
4. Weight is reduced with no sacrifice in strength.
5. Less machining is required.
6. Expense of pattern is eliminated and time for delivery is reduced because time usually required for pattern making is saved.
7. Frames fabricated from rolled steel are more rigid and when properly designed practically free from breakage.
8. Changes where necessary are easily made and production losses are practically eliminated.
9. Less floor space is required in production and flexibility of manufacture is greatly increased.

Flame Machining

As mentioned previously, the principal difference between flame machining and flame cutting is that the former is a process for removing surface stock whereas the latter is concerned primarily with severing metals. In the deseaming of steel billets—one of the major applications of flame machining in the steel industry—surface stock is removed in the form of a shallow groove, the depth of which is so controlled by the operator that the seam or other defect is removed without cutting deepr than necessary.

The nozzle in the blowpipe employed for this work has a comparatively large orifice for the cutting oxygen. Relatively low oxygen pressures are used and since the cutting oxygen stream strikes against the steel at quite an angle, the cut does not penetrate through the work as it does in flame cutting but instead takes the form of a groove as the blowpipe is moved along. By varying the type of nozzle used, the contour of the groove may be varied from oval to one that is more flat. Groove dimensions range from a little less than 1/16 in. in depth and ½ in. in width to 5/16 in. in depth and 2 in. in width, depending on nozzle size, oxygen pressure, rate of travel and angle of nozzle to work. Linear speeds of cutting by the average operator vary from 15 to 30 ft. per min., although still higher speeds are possible.

Where the flame machining blowpipe is machine guided, rates of metal removed in simple planing operations have varied in trial operations from 500 to 1,000 lb. per hour with single nozzles. For turning operations where cutting is continuous, rates have varied from 1,200 to 1,800 lb. per hour. From 2 to



Flame cutting is illustrated diagrammatically at (a) and flame machining is illustrated at (b). In the case of flame machining a groove is being cut from left to right.

2¾ cu. ft. of oxygen are consumed per pound of metal removed.

The major operations possible with flame machining are planing, milling, turning, drilling and boring.

Planing consists of making single or multiple parallel cuts on the surface of a piece, multiple cuts usually overlapping so that surface stock is removed much as in machine tool planing. Deseaming is classified under planing.

In the operation of flame milling, two or more cuts are produced along the same line to make a single groove deeper than possible with one cut. With flame turning, circumferential planing or milling cuts are made on round stock, similar to machine tool turning.

Drilling and boring have not been completely commercialized as yet although preliminary investigations have shown great promise for these operations.

A commercial application of flame drilling which has been developed consists of depressing a round hole in the end of a billet for centering or piercing purposes. Holes of this type can be extended to a considerable depth by use of the oxygen lance.

An important application for flame milling is in the preparation of plate edges for welding. The U type of preparation for butt welds is preferred in pressure vessel construction because it reduces considerably the amount of welding rod needed over the V type preparation. U preparation is readily accomplished with flame milling, either with the plates butted together or separated. In the case of double U joints, flame milling has the important advantage that it can be used in preparing the second U after one side of the joint has been welded. This can be done right on the pressure vessel and the milling cuts can be carried deep enough to uncover sound weld metal at the root of the first U.

Typical milling cut profiles for preparation of U type joints have been perfected, along with the necessary nozzles, and requirements for angle of impinge-

ment, oxygen pressure, and rate of travel; and it is expected that this use for flame machining will see rapid advancement.

The designation, "The universal tool of all industry," frequently applied to the oxy-acetylene process, is indeed appropriate when its wide sphere of usefulness in the scheme of American industry is considered in the light of these recent developments.

Discussion

Discussion presented by

C. O. Franklin, Asst. Electrical Supt., Carnegie Steel Company, Homestead, Pa.
M. J. Henderson, Sheet Metal Department, The B. F. Goodrich Company, Akron, Ohio.
W. S. Walker, The Linde Air Products Company, Cleveland, Ohio.
A. E. Gibson, Vice President, The Wellman Engineering Company, Cleveland, Ohio.
C. Simera, Welding Foreman, Corrigan-McKinney Steel Company, Cleveland, Ohio.
W. H. Moos, Maintenance Foreman, National Tube Company, Lorain, Ohio.

C. O. Franklin: In flame machining is the torch held in an ordinary tool post or is special means provided for supporting the torch?

W. S. Walker: We have a special straight barreled blowpipe, similar to the machine cutting blowpipes on our automatic cutting machines. It can be mounted on almost any machine to give it proper speed control and lateral and horizontal adjustments.

M. J. Henderson: For cutting cast iron, do you have a regular torch or special torch?

W. S. Walker: In cutting cast iron we use the same blowpipe we use in cutting steel. It is sometimes desirable to use a nozzle which has greater capacity for the preheating flames so that the heat gets down and carries through deeper in the kerf.

M. J. Henderson: I would like to know if you have any different material outside of the high test rod for welding pipe?

W. S. Walker: Are you referring to a particular trade name or general classification?

M. J. Henderson: General classification.

W. S. Walker: For welding pipe by the oxy-acetylene process my company has two rods which give unusually high tensile strength and good physical properties. One is for use for the full fusion method of welding and the other has been developed for the Lindeweld process, which I described.

M. J. Henderson: That is what I mean.

W. S. Walker: It is a special rod compounded with the proper ingredients for the purpose.

M. J. Henderson: For 1,000 pounds pressure?

W. S. Walker: It is our endeavor to develop the full strength of the base metal within reasonable limits. Of course, we have made some rather spectacular tensile tests under special conditions in the laboratory. I have seen many of them go over 100,000 pounds without any heat-treatment after welding.

A. E. Gibson: In answer to the gentleman's question, I think he would probably be interested to know of some experiments we carried on these last two weeks in which we developed yield points over 90,000 pounds per square inch, tensiles of over 110,000, and elongation of 2 inches across the weld of over 26 per cent. That was with a heavily coated electrode, with an alloy composition in the coating. Those results were after a stress relief at 950 degrees. The analysis of this steel was 1.40 copper, .25 molybdenum, and about .25 carbon steel, and in all cases the parent metal fractured instead of the weld. It had a Rockwell hardness of somewhere around 97 to 100.

I wonder, Mr. Chairman, if I might just take a moment to show these people a sample of steel which I think they would be very much interested in, and particularly all of us who are engaged in welding, especially on highly stressed welds that are subjected to failure from constant reversal. This particular piece of steel (Fig. A) doesn't happen to be a weld but is a piece of a steam hammer die that failed in service at one of the steel mills in Cleveland. Knowing that I was interested, they brought it to me to show the effect of concentrated stresses on any piece of steel in which the continuity of surface is broken so that very large concentrations of stresses occur at the change of surface. That is just such a thing as we encounter continually in the welding process, particularly where we do not get complete penetration of the weld.

FIG. A.

It almost looks as though this fracture might be a design for a radiator cap of an automobile. You are familiar with the method in which a block is fastened to the hammer piston. In the manufacture of this, they took all the precautions possible by rounding out the corners of that keyway in order to prevent a fracture starting at the sharp corners. This keyway is pretty well burred over, but on the reverse side you can see the rounded edges that were machined in the keyway.

You will notice radiating from the corners of the keyways the lines of force which have been permanently recorded in the fracture. They start out from the sharp corners with long sweeping curves and you will notice that before the piece fractured completely, there was another crack set up some three inches from the keyway. In the continual working of the hammer before it failed, you will notice that from this secondary fracture other concentrations of stresses took place which turned the stress lines right down into that crack.

It is one of the most interesting physical examples of what we get in welds. For instance, where you take a joint like this, a V, you lay in a bead, and if complete penetration is not obtained at the bottom of the weld, and the part is subjected to con-

tinual reversal of stresses, a crack is provided that is just a beautiful starting point for a failure.

W. H. Moos: When applying your Stellite, is it necessary to preheat the part before applying the Stellite?

W. S. Walker: That depends entirely upon the size of the piece and the material it is made from.

W. H. Moos: One by four by twelve. That would be a hammer mill flail.

W. S. Walker: You are speaking in terms of inches, aren't you?

W. H. Moos: Yes, sir.

W. S. Walker: What is the material?

W. H. Moos: Rolled steel, 0.60 per cent carbon.

W. S. Walker: Is it applied along the thin edge or wide surface?

W. H. Moos: Wide surface. The reason I asked that is that we have tried both and it is more expensive with oxy-acetylene welding because they had to preheat. I wondered if there was a way we could do this without preheating. In electric welding we can do it in the mill without taking it out.

W. S. Walker: The object of preheating was to prevent distortion.

W. H. Moos: Our salesmen said we would have to preheat with oxy-acetylene, and so I can see the idea of trying electric welding which we can do in the mill. Where there 270 hammers in a mill it would take considerable work to take them out. I wonder if there are ways and means of welding them in place with oxy-acetylene?

W. S. Walker: Haynes Stellite can be applied by either method. We get a little better results by the oxy-acetylene method because the flame is adjusted to give an excess of acetylene in the flame, commonly called a reducing flame. In this manner the base metal is prepared to receive the Stellite by a sweating action and we get a little stronger bond. Now the object of the reducing flame is not only to keep the weld and base metal at the joint clean and free from oxidation but also to deposit a thin film of high carbon content metal on the base metal surface, a few thousandths of an inch deep. As you know, the melting point of steel reduces—according to the diagram with which we are familiar—as the carbon content increases. This thin film on the surface becomes fluid because of its carbon content at a temperature at which the base metal is still a solid, making possible a bond between the Stellite and the steel without mixing the two.

Stellite can be deposited electrically, but you don't have all the advantages that you have when using the gas flame. I usually use the oxy-acetylene flame wherever I can and the only thing that really limits it is a case similar to the one you mentioned, where distortion occurred. Preheating will reduce the amount of distortion. It might cost a little more than electric deposition but I think you will get a better finished job and it will last longer.

C. Simera: I might say the cost of Stelliting would be increased if Stellite was applied in a vertical position. The same would be true if it were used as an electrode and deposited electrically. You could not get as thin a layer as you would obtain in using the acetylene method of application. In depositing it electrically it would become mixed and contaminated with the parent metal. This, of course, is not desirable.

W. S. Walker: I am glad Mr. Simera mentioned that. It reminded me of another point. That is, you have a spatter loss when you deposit the material electrically, and in addition to the losses Mr. Simera mentioned there is a lot of Stellite that goes into the air and never gets on the steel. This does not happen in the case of gas welding. Stellite is an expensive welding rod, speaking in terms of the usual steel rod, on a per pound basis; but it often proves to be very inexpensive if used in the proper places to reduce wear on metallic parts, and to prolong their life many times.

JOURNAL OF THE BRITISH IRON AND STEEL INSTITUTE

In reviewing the Journal of the British Iron and Steel Institute, released September 1934, there is found much of interest to the membership of the A. I. & S. E. E. In section 2 of this Journal, which contains notes on the progress of the home and foreign iron and steel industries as reported in the proceedings of scientific and technical societies, there is liberally distributed many references to the complete and comprehensive papers having appeared in the Iron and Steel Engineer. It is felt that this recognition is another indication of the fine technical work being done by the A. I. & S. E. E.

▲

STEEL PAYROLLS INCREASE 12% DURING OCTOBER

Payrolls of the steel industry were higher by $3,581,017 in October 1934, than in September—an increase of more than 12 per cent, according to a report released by the American Iron and Steel Institute.

The October payrolls totalled $32,723,909, as against $29,142,892 for the preceding month. Although steel operations in October were 50 per cent less than a year ago, last month's payrolls were only 17 per cent less than in October, 1933 when the total was $38,334,978.

Total number of employees in the steel industry was 381,431 in October, 1934, about the same as September's total of 381,828. During October, 1933, the industry employed 416,277.

Average number of hours worked per week by employees in October, 1934, increased 11 per cent from the month before. Employees averaged 26.8 hours per week in October, compared with 24.2 hours in September and 32.1 in October, 1933. Average earnings per hour for all employees were 72.3 cents in October, 1934; 73.8 cents in September, 1934; and 64.8 cents in October, 1933.

	Oct. 1934	Sept. 1934	Oct. 1933
Employees	381,431	381,828	416,277
Payrolls	$32,723,909	$29,142,892	$38,334,978
Hrs. per Week per Employee	26.8	24.2	32.1
Av. Earnings per Hour	72.3¢	73.8¢	64.8¢
Operating Rate	24.59	22.74	36.89

General view from finishing end of the Inland Steel Company's 76" hot strip mill located at the Indiana Harbor Plant.

76" Hot Strip Mill, Inland Steel Co., Indiana Harbor, Ind.

By R. W. DAVIS
Electrical Engineer, Allis-Chalmers Mfg. Co., Milwaukee, Wis.

Paper presented at the A. I. & S. E. E. Annual Convention held in Cleveland, Ohio, September 18, 19 and 20, 1934.

Mill Building

The mill and its accessories are housed in a group of buildings covering an area of 340,000 sq. ft. The hot strip mill building proper is 105 ft. wide by 600 ft. long and is served by two 60-ton cranes.

Parallel to the mill building itself is the motor building containing the main mill motors, their supporting motor-generator sets and all control equipment, having a combined length of 600 ft. and an approximate width of 60 ft. The motor room is served by a 50-ton crane.

Alongside the motor room and furnace building is a closed slab yard 85 ft. wide and 350 ft. long equipped with two 25-ton cranes. At the south end of the mill building proper and forming a continuation therewith, are two buildings each 105 ft. wide by 1100 ft. long. These buildings are connected to form an unobstructed floor surface to house the hot bed, run out tables, coilers, flying shears, piler, tie transfer plate, shearing equipment, sheet pickling and shipping department. They are served by six 15-ton cranes. All buildings are of modern steel mill type of construction.

Slab Yard

Slabs are delivered from No. 2 Plant to the slab yard where they are unloaded by means of a 25-ton magnet crane, this same crane placing them in the magazine charger which dispenses one slab at a time to the furnace charging table. Whether the slabs are placed on the charger by means of magnet or sling chains depends upon the size and number of slabs.

Furnaces

Each of the three furnaces has a double head pusher with a 15 ft. stroke and heads can be operated together or separately. Each of the reheating furnaces which are of the Rust three-zone, triple-fired type using oil as a fuel, have a width of 18′ by 77′ length from charging door to brow. The hearth of these furnaces is practically level. Furnace roofs are of the American suspended arch design and are provided with recuperators of the Chapman-Stein refractory tile type.

The discharge end of the furnace projects into the mill buildings and the skid plates of the delivery

table are especially designed to allow the discharge of the slabs without undue shock to the table and its roll.

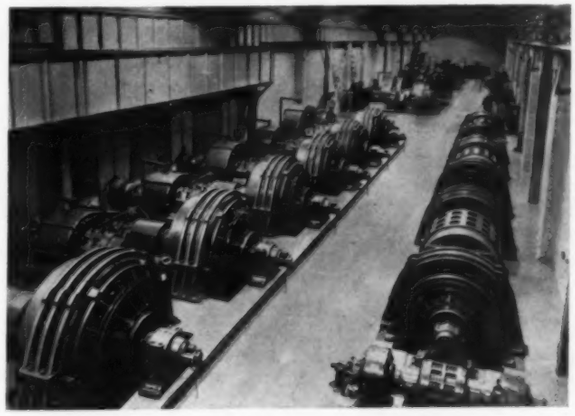
The rated capacity of each furnace is 50 tons per hour.

Mill

The mill proper was built by the Mesta Machine Company and contains essentially, the following:

No. 1 scale breaker.
Chain transfer and turn-over device.
Slab turn around table and screw pusher.
No. 1 or spreading stand.
A second slab turn-around device and motor driven hydraulic squeezer.
Nos. 2, 3 and 4 roughing stands with vertical edgers.
No. 2 scale breaker located about 99 ft. away from No. 4 roughing stand.
Nos. 5, 6, 7, 8, 9 and 10 finishing stands.
Between stands 5 to 10 inclusive are torque motor operated loopers.

The first scale breaker is a two-high mill with rolls 23" in diameter by 76" face and is driven by a 1000 HP, 375 RPM wound rotor induction motor.



General view of the hot strip mill motor room.

The chain transfer between scale breaker and No. 1 stand is driven by 35 HP motor.

The slab turn-around table is driven by 7½ HP motor and slab pusher for entering the slab squarely in the rolls of No. 1 stand is driven by 150 HP motor.

No. 1 stand is a four-high universal type having 36" diameter working rolls, 49" diameter back-up rolls with a length of 96". This stand can be used for cross-rolling, for spreading, in which case the slabs are limited to a length of approximately 87". Immediately after the No. 1 stand is a hydraulic slab squeezer for correcting the widths and squaring the edges. No. 1 stand is driven by a 3000 HP, 150 RPM wound rotor motor having a heavy flywheel.

Mill stands Nos. 2, 3 and 4 are also of the four-high universal type with vertical edger rolls on the entering side.

The working rolls on these roughing stands are designed for operating at 25" diameter with back-up rolls 49" diameter with a working roll length of 79" and a back-up roll length of 77". These three stands are each driven by a 3000 HP, 500 RPM wound rotor motor and together with No. 1 stand constitute the roughing end of the mill.

On this end of the mill are two 1000 GPM, 1000 pounds pressure hydraulic pumps, each driven by a 1000 HP, 750 RPM Allis-Chalmers wound rotor induction motor and used for scale removal after the slab passes through the scale breaker.

Inasmuch as this paper is essentially concerned with the finishing end of the mill, the foregoing is given to roughly outline the process before entering No. 2 scale breaker ahead of No. 5 or the first stand of the finishing mill train.

Products

The mill has a rated capacity of 2000 tons per 24 hours or 50,000 tons a month.

The slab sizes delivered to the slab yard from the 40" blooming mill in #2 plant will vary from approximately 18"x3"x60" up to 41"x4½"x168" with weights varying from a minimum of approximately 1000# to a maximum of 7500#; depending upon the final width and gauge to be rolled.

The mill is designed for the rolling of strips, sheet and plate of the following dimensions:

	Thickness	Min. Width	Max. Width
Plate	3/16" to 3/4"		72"
Strips and sheets	0.042	18"	36"
	and of various gauges and widths from these minimums up to and including 0.076 thickness and 74½" widths.		

The latter values indicate the lightest gauge of the widest sheet rolled. Between the limits given the maximum width will be limited by the gauge, for example 16 gauge is rolled to 60" width.

The composition of the steel rolled will ordinarily be low carbon. However 1% manganese steel is also frequently rolled and have rolled 1.35% manganese.

The rolling temperatures will vary somewhat with the composition and the gauge requirements. Ordinarily slabs will be delivered from the furnaces at a temperature of approximately 2250° F. and the finishing temperatures will range from 1700° F. downward to approximately 1350° F.

The coilers have sufficient capacity, and strip is

General view of the control and relay panels.

often rolled up to 650 foot length but such length is ordinarily limited to 16 gauge.

Finishing Stands

As previously stated #2 scale breaker is located approximately 99 feet away from #4 mill stand. The rolls of this breaker are 24" diameter by 76" working face, i.e., as far as size is concerned, it is the same as #1 scale breaker. It is driven by a 500 HP, 150/450 RPM direct current motor built by our company.

Stands #5, 6, 7, 8, 9 and 10 are of the four high type with 24½" diameter rolls 49" diameter back-up rolls and the working face of 76" in all stands. These mill stands have roller bearings on the working and back-up rolls. All screw downs are motor operated through magnetic clutches and screw-down gauges are calibrated in one-thousandths of an inch.

Each of the finishing stands are driven by 3500 H.P. 600 volt, 175/350 RPM adjustable speed, direct current motors.

Delivery Speeds

All gear ratios between motors and mill stands are indicated by the following table:

Mill Stand	Roll R.P.M.	Motor R.P.M.
# 1	19.11	150
# 2, 3, 4	64.11	500
# 2 scale breaker	16.91/50/73	150/450
# 5	27.6/55.2	175/350
# 6	43,7/87.5	175/350
# 7	59.4/119.8	175/350
# 8	76.4/152/8	175/350
# 9	91.7/183.5	175/350
#10	105.4/210.8	175/350

Based on this table it will be evident that with 24½" diameter working rolls the delivery speeds will vary from

Minimum	Maximum	
177 F.P.M.	354 F.P.M.	in # 5 stand
up to 776 F.P.M.	1352 F.P.M.	in #10 stand

Between each finishing stand is located a constant torque-motor operated looper. Between stands 9 and 10 however the material is ordinarily rolled in tension so that the motor operated looper is inactive except as its roll is used to support the strips passing over it. The use of the looper between the last stands is at the discretion of the operator and may be put in operation at any time it is desired.

Rolling in tension between the last stands increases the horse power requirement of the #10 stand motor by about 200 to 300 H.P. The tension is only sufficient to prevent increase in width of strip or sheet.

Drafts

When rolling sheet the draft through the finishing stands will be approximately as follows: Stands #5, 6 and 7 from 30 to 45%; stands 8 and 9 from 20 to 30%; stand #10, 10 to 15%.

When rolling plate the drafts will be approximately as follows: Stands # 5, 6 and 7 (based on ¼" plate) will be approximately 20 to 30%; stands 8 and 9, 10 to 20%; #10 stand 5 to 10%.

It is interesting to note that the working rolls are changed after approximately 1000 tons have been rolled when rolling the thinner gauge sheets. Another item of interest in connection with the stands is that the time of changing rolls has been put down to a minimum.

For instance, all rolls in the six (6) finishing stands have been changed in the record breaking time of 36 minutes. The importance of this is obvious, when it is considered that the time during shut-down is valued at $3.50 to $4.50 per minute.

Power Supply

The roughing mill motors with their control, the variable frequency sets and the vertical metalclad switchgear were furnished by another manufacturer.

The finishing mill motors with their control and supporting synchronous motor-generator sets, the mill supply M.G. sets and metalclad switchgear were furnished by our company.

The power is delivered from the mill power house at 3 phase, 25 cycle, 6600 volts to all A.C. motors 1000 H.P. and larger and at 440 volt for motors of smaller rating. All main driving motors with their speed reducers are located in the motor room which in addition contains the following:

3—5000 KW., 600 volt D.C., 500 RPM synchronous motor generator sets.

These sets support six 3500 HP direct current motors on the finishing stands as well as the 500 H.P. motor on the No. 2 scale breaker. In addition they support the variable frequency changer sets supplying the mill delivery, hot bed approach tables and strip coiler motors.

1—250 KW., 250 volt D.C., 750 RPM synchronous motor generator set supply excitation for synchronous motors, direct current generators and the direct current mill motor.

3—1000 KW., 250 volt D.C., 750 RPM synchronous motor generator sets supplying auxiliary power.

The magnetizing, starting and running oil circuit breakers for the synchronous motor of the sets are of the metal clad type.

4—Variable frequency motor generator sets each consisting of two 300 volt, 300-1200 RPM, direct current motors driving 15/60 cycle alternators.

In the motor room are located other auxiliary apparatus motor driven air compressors, the control board for the starting of the motor generator set, etc.

Finishing Stand Speed Adjustment and Regulation

Two methods of obtaining motor speed reguation offer themselves. One is by means external to the motors and generators themselves such as by use of IR drop exciters, etc., the other is by so arranging the internal arrangement and connections of the winding of the motors and generators involved in such a manner as to make a fine speed regulation inherent in the machine themselves. This latter method was resorted to in this case.

Each 3500 HP motor on the finishing stand can be supported from its individual 2500 KW, 600 volt direct current generator. Under ordinary conditions motor and generators will be operating in parallel.

The starting of the direct current motors is accomplished by variable voltage on the direct current generators, but all speed adjustment of the motors is by field weakening with the generators operating at pre-determined constant voltage somewhere between 450 and 600 volts. Likewise, any desired combination of individual or parallel operation is provided for i. e., say for instance it should be necessary that shut-down one motor generator set the other two sets may be operated in parallel, or some of the motors may be operated individually from their own generator and the balance of the motors and generators be paralleled.

The 3500 HP motors are shunt wound and in addition have a speed rgulating winding. This speed regulating winding in turn is connected in series with an adjusting rheostat, this in turn being direct coupled to the main shunt field rheostat. With full field on the main motor, the regulating winding rheostat will be practically all cut in, as only the minimum effect is then required from the speed regulating winding. This arrangement of equipment gives close inherent regulation of the motors.

The main features of the control are as follows:

1—Equalizing winding on generators to equalize the load when motors are brought up to speed with generators operating in paralled and before regulators become operative at the pre-determined full generator voltage.

This equalizing winding becomes in-operative when motors are operated individually from their supporting generator.

The winding assists the voltage regulators when the generators are operating in parallel at the predetermined full voltage (see 2).

2—Equalization at constant voltage with regulators.

Voltage regulators are so arranged that they may be adjusted for five different operating voltages in steps from 450 to 600 volts maximum.

Compensating winding is automatically cut out during individual operation and regulators maintain constant voltage.

Speed regulation is a paramount requirement and specified limits in regulation become very exacting. To obtain such a motor speed regulation, guarantees must necessarily be based on constant voltage at the motor terminals. Regulation of the D.C. bus voltage then becomes a vital factor. In the larger power drives physical limitations make it necessary to operate the D.C. generators in parallel. From the standpoint of control, it is convenient and customary to use shunt generators and further more the inherent drooping characteristics of such generators admit of successful parallel operation.

More definitely when operating D.C. generators in parallel beside the prime requisite of constant speed prime movers, each generator must tend to shirk its load with load increases on the bus. However, with generators operating on a common bus where points of connection are sufficiently close together so that the lead resistance is negligible, each generator must impress equal voltage at the point of paralleling and the distribution of current and voltage through parallel machines will adjust itself until this result is obtained.

In an installation such as this hot strip mill, where full load is thrown on motors successfully as the strip enters successive rolls, widely and rapidly fluctuating loads must be delivered from the generator bus. This fluctuation calls for regulators for maintaining constant bus voltage.

However, where individual regulators are used, the drooping characteristic must be maintained on each generator to give satisfactory operation. Experience has shown that in order to keep the unbalance in current between generators within reasonable limits, this droop must be approximately 4%. Obviously with this droop, an increase from no load to full load on the bus will cause a 4% drop in bus voltage and this drop would make it impossible to maintain close motor speed regulation.

Therefore, to obtain constant bus voltage and at the same time maintain equal loads on all generators, compensating means which are postive and rapid in action are used to accomplish results equivalent to equalizers used on compound machines.

When a load is thrown on d-c generators operating in parallel, and unbalance in load distribution between machines is very likely to occur even though the generator characteristics be as carefully proportioned for parallel operation as manufacturing tolerances will allow. Such items as brush fit, difference in resistance of field and armature windings at different temperatures, etc., will be sufficient to cause such unbalances. The load unbalances are the result of differences in voltage between generators at the point of paralleling.

To correct the load distribution, either the excitation may be reduced on the machine which has taken more than its share of load or the excitation may be raised on the other machines. In the first case the bus voltage will be reduced by the excitation change, and in the second case it will have the tendency to be raised. Thus, in order to maintain constant bus voltage, it is necessary to reduce the excitation proportion to load increase on the machine taking more than its share of load and to increase the excitation proportionately on the other machines connected to the same bus.

The regulation of voltage then may be arranged to hold a constant value of bus voltage automatically with any load change, within the capacity of the machines controlled, with operation in parallel. Thus is accomplished by providing control elements on each machine responsive to the load on the individual machine and so arranging the connections of these elements that the heaviest loaded machine's excitation will be reduced in proportion to load increase and the excitation of the other machines will be increased in proportion to load differences, respectively.

In practice the voltage regulation is held to ½% and with the special compensating features the bus voltage may be given a slightly rising characteristic with sudden increases in load. Where fast acting regulators and machine fields are used.

With ½% regulation and fast operation equipment the load distribution between machines will be held to approximately 6.25% unbalance between machines.

In practice it has been found that the distribution has been held within considerable closer limits.

There is individual voltage regulator control elements installed with control switches and compensating rheostat controls on individual panels for three generators operating on a common bus.

The regulators are arranged to be set for six different voltage settings by six position control switches. Transfer switches are provided to allow individual setting of the voltage for single machine operation and also to operate the voltage settings from a single group switch for parallel operation.

The flexibility of control of such a regulating system admits of application to any combination of generators which may be expected in practical applications. Furthermore, the generator bus may be arranged in any desirable manner to best accommodate the load requirements.

3—Special quick acting trip coils on all motor and generator circuit breakers are provided in order to furnish high speed trip for protection against flash-over. At the instant of any tendency to flash-over the circuit is cleared before current has time to reach excessive value. The breakers as first installed had ordinary trip coils which were found to be not fast enough. For this reason, direct current relays connected across the interpole winding were added, these relays depending on the inductive kick due to the load current rise and provided the desired result of high speed tripping.

4—Operator's control. In the operator's pulpit is located a bench-board providing for the following:

Control set up for individual or parallel operation. Control of operating voltage by setting of voltage regulator at the pre-determined desired voltages in accordance with (2).

Speed control of motors by motor operated main shunt field motor rheostat and hand operated Vernier rheostats on each motor.

One item of special interest in connection with the finishing stand motor control scheme is that the variable frequency motor generator set supplying variable frequency alternating current to the mill delivery table is interlocked with the control of the motor and generator of No. 10 finishing stand. This is so that as the mill delivery speed is increased, the mill delivery table rolls will automatically increase proportionately in speed.

The relative speed between successive stands is directly under the control of the mill operator.

Hot Bed

Leaving the hot mill building, the strip is carried to the hot bed in the finishing plant on a run-in table 300 ft. long having individual variable frequency induction motor driven rollers. This run-in table goes over to the two 74" Mesta coilers.

A table chain transfer connects with the center table and provides two-run-outs to tables on either side. The variable frequency motors on the rollers provide adjustment in delivery speed from 345 to 1380 feet per minute.

At the end of each run-out table is a 17 roll leveler and approximately 265 ft. from the leveler is a 76"x½" end shear. About 267 ft. from that shear is a flying shear and piler.

On the in-going side of the flying shear there is a cross transfer between the two run-out tables so that the plate material can be transferred and returned to the north end of the hot bed building and transferred to the plate finishing building, trimmed on a 72"x½" rotary side trimming shear and cut to the correct length on the third 76"x½" end shear. The dimension of the coils are, inside diameter 24"; maximum outside diameter 36"; minimum width 18"; maximum width 73"; maximum thickness about 3/16".

Discussion

Discussion presented by

S. Badlam, Consulting Engineer, Pittsburgh, Pa.
R. W. Davis, Electrical Engineer, Allis-Chalmers Mfg. Co., Milwaukee, Wis.
L. A. Umansky, Industrial Engineering Dept., General Electric Company, Schenectady, N. Y.
F. O. Schnure, Electrical Superintendent, Bethlehem Steel Company, Sparrows Point, Md.
C. J. Smith, Electrical Engineer, Illinois Steel Company, South Chicago, Ill.
G. Fox, Vice President, Freyn Engineering Company, Chicago, Ill.
J. O'Malia, Electrical Engineer, Otis Steel Company, Cleveland, Ohio.
A. J. Standing, Electrical Superintendent, Bethlehem Steel Company, Bethlehem, Pa.

S. Badlam: I would like to ask Mr. Davis if he has any figures on the maximum horsepower developed by finishing mill motors, at the Inland mill, and for how long a period?

R. W. Davis: Well, on one particular set up they tie the breaker in and they don't think they have any load at all until they are over a double load.

S. Badlam: Over 7,000 HP.?

R. W. Davis: Yes. We have pulled 2½ and 3 times full load on the last pass when rolling floor plates. On strips I believe the normal overload goes up to about double load maximum, and of course the duration is a function of speed and length of piece.

S. Badlam: It is hardly over forty-five seconds, is it?

R. W. Davis: I wouldn't be surprised. It is hard to say because the strips will vary up to 650 feet long down to short pieces, so you get a wide variation in length of pass.

L. A. Umansky: It is always a pleasure to hear Mr. Davis' papers and participate in their discussion. Today's occasion is no exception to this rule. I hoped that Mr. Davis would give us today his views on special requirements, if any, of electric drives for hot strip mills, particularly for the finishing stands. However, his presentation was primarily of a descriptive nature,—very interesting and instructive, to be sure,—but not of a controversial character. Since our meetings are always of more interest to the membership when a difference of views is being aired in the open, I will initiate the discussion myself and hope that others will join the issue.

More often than not, when a new continuous hot strip mill is considered, the speed regulation of the d-c. motors for the finishing stands is brought into the picture. These stands are individually driven by separate motors. The strip is in all finishing stands simultaneously. Hence,—many argue,—these motors should change their speed but little from load to no-

load condition. Their speed regulation, it is said, should be as close to zero as possible. I do not know where this idea originated, but it certainly can not be substantiated neither in theory nor by experience. Let us try the theory first.

What is the "speed regulation" of a d-c. motor? The A. I. E. E. rules define it as the change of motor speed from full load to no-load, expressed in percent of the full load speed. Thus, for instance, if the full load speed is 200 rpm., and the no-load speed is 204 rpm., the speed regulation is 2%. A "normal" d-c. rolling mill motor, with a 2:1 speed range by field control, has a speed regulation of not more than 4% at basic (full-field) speed, and of not more than 2% at the maximum speed. If a closer speed regulation is required, such additional means as series exciters or equivalent, may be furnished, to limit the speed regulation to about 1½% throughout the speed range. This, of course, brings the motor price up. A still closer speed regulation, about ¼% throughout the entire speed range may be also guaranteed. More or less elaborate speed regulators are then required and the extra price which the purchaser pays goes, of necessity, still higher. My contention is that this extra expense can not be justified, and that it constitutes nothing but waste of money on the part of the steel industry.

It is self-evident that if the several tandem stands are working simultaneously on one piece of strip it is vital to adjust very accurately the relative speeds of the adjacent motors. Otherwise, the metal may stretch or loop excessively between the stands. Fine adjustment, or vernier, field rheostats for the several motors are indispensible. The relative motor speeds are adjusted by the operator when he observes the moving strip, i. e. when the motors are loaded. The motor speed may go slightly up, when the metal leaves the rolls, but it will go down to the original and proper value after the next bar enters the rolls. Hence, the speed relationship between the empty stands is of no practical importance. Why, then, be interested in the change of motor speed from load to no-load, when only the load speeds are in the picture?

I see only one argument—and a not very strong one at that—in favor of close speed regulation. It may assist the operator in pre-setting more accurately the relative no-load speeds of the several stands, requiring less final re-adjustment when the trial bar or bars go through the rolls. This advantage is more imaginary than real. How are the speeds of the several stands pre-set? Someone in the mill superintendent's office, or the roller himself must figure out the drafts to be taken on each of the tandem stands. Then the roller must set the screwdowns to correspond to these drafts. If he sets them within 1 or 2% of the proper value, he is extremely lucky, as may be witnessed by anyone who had tried to do this work himself. With the assumed drafts and known roll diameters, someone must calculate the required motor speeds. Thus far a potential error of not less than 2% (and usually much higher) has already crept in. Next thing is to set the motor speeds at these calculated values, using tachometers as a guide. Now these meters are usually accurate only up to 1% of their full scale. If a reading is taken somewhere in the middle of the scale, the potential error may be as high as 2%, even with a brand-new instrument. If all these errors are added together, it is obvious that no tandem mill speeds may be preset in advance any closer than 4-5% from the true values which the operator will finally establish watching the metal go from stand to stand.

I am inclined to believe, therefore, that even this sole argument in favor of a closer speed regulation than a normal motor can give is not worth much from a practical standpoint.

Now, let us check the experience of hot strip mills of this type, a number of which are in operation for several years.

The Butler mill of the American Rolling Mill Company was installed in 1926. Its four finishing stands are each driven by a 2000 hp.-200/400 rpm. d-c. motor. No one had even discussed the speed regulation of these motors when they were purchased. Standard regulation was provided, and nothing closer was found necessary in the 8 years of actual operation.

The drives for the Weirton 48" wide strip mill were purchased in 1926, before the Butler mill had started. The last finishing stands are driven by d-c, motors, with a 2:1 speed range. The matter of speed regulation closer than normal was discussed and, to "play safe," series exciters were provided for the d-c. motor exciters. As far as I am aware, these exciters were never put in service, after it was found that the normal motors give the operators all that they need.

The hot strip mill at the Warren Plant of the Republic Steel Company (then Trumbull Steel Company) was rebuilt in 1927 on the continuous principle. The three finishing stands are each driven by a 2000 hp. Scherbius equipment, originally purchased for the cross-country mill. Now these veteran a-c. motors have given a very good account of themselves in the 15 years of service since they were installed. However, a close speed rgulation, from load to no-load, is not a strong point of these drives, which were never built around this characteristic. A regulation of 5% or more is on hand. And yet, this mill rolls hot strip as successfully as any other.

The 60" Steubenville Mill of the Wheeling Steel Corporation was laid out in 1928. The new mill builders and the new purchaser again decided to "play safe" and the several d-c. motors driving the finishing stands were purchased with series exciters, to obtain the "close speed regulation." The rest of the story is the same, of course. The series exciters were installed, wired, tried out, and then disconnected. The strip is rolled successfully ever since without these exciters. Therefore, this "ginger bread" may just as well be dispensed with.

The continuous strip mill of the Great Lakes Steel Corporation was built in 1929-30. Normal motors were provided for all stands. No one talked speed regulation, no series exciters were called for. As the result of this the purchaser had saved money, had avoided the superfluous complications, but is rolling A-1 strip, just the same.

Last, but not least, the Otis Steel Company's 72" wide mill, is equipped with motors of normal design. The operators control the motor speeds with ease; they either maintain the loop between the stands or keep the strip slightly taut; the fine adjustment rheostats take care of this point, and nobody seems to

care about speed regulation from full load to no-load. Now, this mill rolls strip practically as wide as the Inland mill. It is but fair to assume that motors of same design as at Otis (the rating is also identical, 3500 hp.-175/350 rpm.) would drive equally well the Inland mill, no special speed regulation being required.

I believe, gentlemen, that I have proven my point fully, first by the process of reasoning, then by the established operating facts. To my way of thinking, any one buying hot strip mill drives and specifying a speed regulation closer than a normal motor would give—is wasting his, or his company's, money. Maybe the electrical manufacturers should not protest against some additional and easy income! But, if I would try to convince a man, or even if I would agree with him that he should spend an extra price for close speed regulation,—I would feel guilty of being engaged in a "speed regulation racket."

There is another reason why I feel rather sorry about the misuse of this term. The A. I. E. E. definition of speed regulation, given above, is apt to confuse many electrical engineers, and almost all rolling mill operators. Suppose a d-c. motor is running light at 204 rpm. A load is suddenly applied. The motor speed dips down to, say, 192 rpm. and then, in a second or so, it recovers to 200 rpm., and stays there as long as the same load lasts. Now the A. I. E. E. definition takes into account only the speed difference between the "steady-state" or stabilized conditions, i. e. 200 rpm. at the one hand and 204 rpm. at the other hand; thus a 2% speed regulation is arrived at. But the transient dip of speed to 192 rpm., or 6%, is not accounted for by the A. I. E. E. rule. This "impact speed drop" is something of an entirely different nature. We may have a motor with an absolutely "flat speed regulation," i. e. its steady speed under load equals exactly no-load speed; and yet the impact speed drop may be appreciable. Likewise, another motor may be built, with a poorer steady-state speed regulation (as defined by the A. I. E. E.) than the first motor, but with a much smaller value of the impact speed drop.

Most of the mechanical engineers and rolling mill operators, insisting—rightly or wrongly—on motors with close speed regulation, believe that they are also avoiding the momentary or impact speed drop. Usually they do not. Series exciters, special speed regulators, and other expensive contraptions, have little or no effect on this transient occurrence. Other means must be employed to overcome this motor characteristic, but time does not permit us to discuss these means today.

As far as the hot strip mills are concerned, the impact speed drop is usually found to be a "blessing in disguise." On its account a small loop is usually formed between the adjacent stands at the very beginning, and then the loop does not grow any larger or smaller, provided the load speeds were properly set.

For other than strip mills the impact speed drop might be far less than a blessing. But we must leave this topic to another, more opportune time.

R. W. Davis: I am very glad Mr. Umansky has brought out this characteristic of impact drop. That is entirely unessential in a strip drive. Any D.C. motor, as he has illustrated, has a transient drop in speed that may affect the product, in certain cases for example, in the continuous tube rolling mill where the tube is rolled over a rigid bar, that does not at all apply in strips.

In the strip field there has been quite a change in thought regarding speed requirements. I can remember some of the early mills where they wanted an eighth of one per cent. I believe the General Electric Company supplied some equipment to meet that guarantee. We frankly said we couldn't do it. Later it was a quarter of one per cent. Then it switched the other way—two and four per cent.

It is not absolute regulation that is important; it is the relative regulation between successive stands with a piece in the same stand. If you are looping, as in most cases, it doesn't make much difference what speed regulation you have. If, however, you come to tension rolling, then a moderate speed regulation will, I believe, give an easier mill to operate. But I can't see any call for these very close speed regulations in a strip mill of an eighth or quarter per cent. If you can get around one to 1½ per cent throughout the speed range it will give you an easy mill to operate for rolling in tension. If you have a two to four per cent it is perfectly good when you are operating with looping. You can also operate a two to four per cent mill in tension but it means a little bit faster operator. It is harder for him to control the pull. It is is a question of degree, as I see it. Mr. Umansky, isn't that about it?

L. A. Umanksy: I was very glad to hear Mr. Davis express his opinion. I still fail to see any connection between the looping of the strip between the stands and the speed regulation of the driving motors. Mr. Davis did not refute any of the arguments which I have brought today. I agree with him, however, that we can hardly settle this argument today.

F. O. Schnure: I have one question to ask. Mr. Davis, and that is, if he had to do it over, in view of the loads that are experienced on the last stand, whether he would recommend a larger motor for that stand?

R. W. Davis: They didn't know they were going to make floor plate. It was laid out for strip and plate. The floor plate came in later, and it is on floor plate they get the excessive loads. Under normal operation the loads on all stands stay within the double load of the motor, ordinarily not over 50 per cent of the load. We did not guarantee to make floor plate and we don't guarantee 3 times full load.

C. J. Smith: I think I am a rank outsider when you talk about hot strip mills. At South Chicago we have a 96 inch wide plate mill, and in order to furnish coiled product for the new cold mills at Gary we have made some slight alterations to that mill so that we can roll strips after a fashion, in short lengths, and that might be enough of a basis to enter a discussion on hot strip mills.

Mention has been made here about short circuit possibilities on a mill of that kind. In our mill we have six 3500 horsepower D. C. finishing stand motors and 12,000 kilowatts in generating capacity, operating at about 600 volts. That gives a full load current rating of possibly 40,000 amperes.

Then in case of a short circuit it seems to be anybody's guess as to how many times full load the

short circuit current may be. We were unfortunate in having one spill. We didn't have any idea as to what the current was, but on the breakers which had been tested at 100,000 amperes without even marking the breaker, this short circuit practically wrecked the breaker. It blew off the auxiliary contacts. This indicates the magnitude of the possible short circuit currents when there is a concentration of that much direct current capacity. The precautions taken at Inland are certainly well warranted. We have made some changes on our equipment, too, to minimize the short circuit effects.

Some mention was made here about eliminating the speed meters. Our mill being primarily a plate mill, we are taking care of jobbing business, and during this time when orders are not so good the application of such orders is probably a misfit. However, they have to roll these plates somewhere, and there are a lot of small orders. The mill is set up for one set of drafts and speeds, and then after a few slabs are rolled is set up for something else. When you are doing that kind of rolling you certainly depend 100 or 101 per cent on your speed meters, but as I say, that really isn't the kind of product for that type of mill.

Our motors are practically duplicates of the motors Mr. Davis described for the Inland mill. We find that the load requirements there are well up above 200 per cent of the motor rating. Of course, our mill is a little wider than Inland's. It is called a 96 inch mill and we can deliver plates up to 90 inches or better.

We find for successful rolling it is necessary to keep the breakers set up about 250 per cent of the motor rating. We could set them higher, and have set them higher, but the limit is actually prescribed by the rolling department, from the standpoint of possible damage to rolls, spindles, gears, etc. That is a very satisfactory way to have it set up, since the mill equipment can be more quickly replaced than damaged roll drive motors.

I say we are rolling a strip after a fashion. Our maximum length we can roll is about 440 feet and our delivery speed is low as compared with regular strip mills. It is on the order of 1,000 feet maximum.

One thing we have found, of course, in trying to adapt a plate mill to strip mill is the mill is too close coupled. The spacing between the roughing stands and the finishing mill is not sufficient to get the lengths of slab required to finish a long coil, but, as I said before, our mill is just in the process of being revamped into a strip mill, so maybe we can get around those difficulties and make a real strip mill out of it.

The question of speed regulation has been discussed here by experts. I think in that connection I am something like the man who came home late at night somewhat intoxicated. His wife met him at the door and told him all about his past. She talked to him for about a half hour and then asked him if he had anything to say. He said, "No, I think the subject has been pretty well covered."

G. Fox: The discussion has been interesting. I might ask a question or two.

Mr. Davis mentioned the peak loads in rolling. I think his remarks referred particularly to the finishing stands. It might be of interest if he would discuss the extent and duration of the peaks in the roughing stands and their influence on the motors and drive used.

Mr. Davis mentioned that the roughing and finishing stands could be changed in about 36 minutes. This refers, I believe, to a complete roll change in the mills. It would be interesting if he would remark concerning the intervals involved in changing from one order to another and in readjusting the drafts to suit. I have reference to the rolling of job lots, the sort of work which Mr. Smith has mentioned.

R. W. Davis: As far as the Inland Mill goes, I don't know. That is not our equipment and I paid no attention to the load on the roughing table. I do know, however, at Illinois where we have the roughing end too, that the loads there go up pretty high.

With regard to the change over, the 36 minutes covered the change of rolls in the six finishing stands and the complete time elapsing from the last plate in the first schedule to the first strip in the second schedule, including the set-up change for drafts.

L. A. Umansky: I can answer Mr. Fox's question regarding the roughing end of the Inland mill. Each of the four roughing stands is equipped with a G. E. 3000 hp. slip ring motor and a flywheel of about 45,000 to 50,000 hp.-sec. Slip regulators are employed. I understand that the regulators are usually set to pick up at about 100% motor load. With this setting the electrodes seldom move. Of course, even when the regulator is in its "resistance out" position, there still is a 4 to 5% total resistance in the rotor circuit. Therefore, a flywheel action may be effective even then (particularly for short passes), and the peak load at the rolls may be quite a bit higher than indicated by the wattmeter. It seems that 3000 hp. drives are amply large for the Inland mill.

J. O'Malia: I came in rather late and just about at the ending. We have at our plant a 72" wide hot strip mill that is employing standard motors on the finishing stands and might say that practically 90 per cent of the material going through the mill is rolled tight between stands and do not have any particular trouble with regulation which appears to be the discussion point.

In regard to the last stand, we have deviated from the normal size of 3500 H.P. on the first three stands to 2500 H.P. on the last stand, which we thought was ample to take care of all the loads and has proven itself so.

A. J. Standing: I have had no experience with hot strip but I have had experience with this eternal question of mill speeds. The question as it approaches all of us in the electrical department is the settlement of the argument between what the mill men want and the price of furnishing what they think they want. It comes up in every job we tackle. We have been through three of them, and as it has been pointed out frequently when the job is put in normal operation it operates differently from what was anticipated. That has cost us all money. I am glad to hear the trend toward simplification and consequently cheaper equipment. Would it be possible at a future date through the Association to catalog various types of mills, including the equipment asked for and purchased, together with

equipment as installed and used, something which would in the future build up a primer from which the rest of us could approach a duplicate job and avoid all the controversial arguments relative to speed regulation and whatnot and actually arrive directly at what has proven satisfactory in the majority of similar mills? There may be a time when we will all be willing to admit the mistakes we made in our first application of certain jobs. I think that time is coming, and if we can get to the point where we say definitely we put in such a thing and didn't use it, the ultimate answer we have found is so-and-so; then the rest of the industry can definitely arrive at a proper answer and tell our management, "This is all that has proven satisfactory in a given number of cases and will cost you approximately so much." I think that is not asking the impossible, and I believe it will be worth while to all of us."

Load Factor and Power Cost—A Danger and A Possible Answer

By PAUL M. LINCOLN,
Director, School of Electrical Engineering,
Cornell University, Ithaca, N. Y.

Paper presented at the A. I. & S. E. E. Annual Convention held in Cleveland, Ohio, September 18, 19, and 20, 1934.

Some months ago I received a request from your managing director to present a paper to the Association of Iron and Steel Electrical Engineers on some phase of the metering problem. After a consideration of various possible questions that might be considered, I have decided to present some personal views on the general question of demand measurement—a favorite topic of mine and one upon which I have expressed my views previously. In October 1915 and in February 1918, I presented papers to the American Institute of Electrical Engineers (See Rates and Rate Making, A. I. E. E. Transactions, Vol. XXXIV, page 2279 and Character of Thermal Storage Demand Meter, Vol. XXXVII, page 189) in which the indefinite character of the now prevalent method of measuring demand was pointed out. As indicated in these papers, it is theoretically possible to use two of the generally accepted types demand meters, both perfectly accurate, and have one give a resultant indication twice as great as the other. This comes about because of the possibility of "splitting the peak". To give a specific illustration, let us suppose that service is being sold on the basis of the maximum 30 minute demand and let us suppose further (an admittedly improbable supposition) that a user of this service takes his load for only 30 minutes during given billing period. In order to get some definite figures, let us suppose further that the load during this 30 minutes is 100 kw. A demand meter of the generally accepted type (the so called block interval type) would show a maximum demand of 100 kw. provided it happened to begin the measurement of this block of load at its beginning end at its end. If, on the other hand, the block interval meter happened to begin the measurement of this block of load 15 minutes before the beginning of the load block and end in the middle of the block—at which time the next block would begin—the maximum demand shown would be only 50 kw.—one half the value shown on the first supposition. For other times of beginning and ending the measurement of the block, other values of maximum demand would be shown intermediate between 50 kw. and 100 kw. In other words, the value of maximum demand indicated by the usual (block interval) type of demand meter is indefinite; the value indicated is a matter of chance depending upon the instant at which the meter happens to reset. Many tests have been carried out which confirm this analysis for actual load conditions.

PAUL M. LINCOLN

Furthermore, the block interval type of demand meter recognizes no differences in demand so long as the time during which load is drawn is less than the stipulated demand period. For instance, 100 kw. for 30 minutes will give exactly the same maximum demand indication as 200 kw. for 15 minutes or 400 kw. for 7½ minutes or 800 kw. for 3¾ minutes, etc. Since it is the object of maximum demand measurement to assess upon the user of the service a tariff which shall compensate the supplier of the service for the fixed charges (interest, taxes, depreciation,

etc.) on the plant necessary to render the service, it would seem that the failure of the block interval type of demand meter to recognize any difference between for instance 100 kw. for 30 minutes and 800 kw. for 3¾ minutes constitutes an indictment of that method of measurement.

As indicated above, it is ridiculous to assume that a user of electric service will take load during a given billing period for only 30 minutes or even for 30 minute periods that are separated by any considerable periods of time. But it is obvious that the load during a given billing period is not constant and that during some 30 minute interval, the load drawn is larger than during any other 30 minute interval of the billing period. It is the function of the maximum demand meter to determine the value of the load during that maximum 30 minute interval. The type of demand meter in almost universal use in the U. S. for this purpose is the so called "block interval" meter. As indicated above, it is theoretically possible for two such meters on the same load to give results differing by as much as 100%. In actual practice, so large a difference is admittedly impossible but differences of as much as 15% have been noted and differences of as much as 5% are quite common. This has been shown by actual tests on loads of varying characteristics. I submit that a measuring device with so large a possible error as this is not a proper one for measuring a quantity upon which is based a very considerable part of the bill which a power company charges for the services it renders to its customers.

In the past, this question of inaccuracy in the method of measuring maximum has not been raised because it has always been customary to use only one maximum demand meter on a given load and its indication has been tacitly accepted by both the buyer and the seller of the service to be correct. If it had been general practice in the past to install two block interval meters on each load so adjusted that their time periods "break joints"—that is, so that the time period covered by each overlaps the other by one-half—this question of the inherent inaccuracy of the method would have been raised long ago. It should be particularly borne in mind that the inaccuracy of the block interval meter is not one of measurement but one of principle of operation.

What is the answer to this problem? One answer is to substitute for the block interval type of demand—which measures the arithmetic average use over a given time—a type of demand meter which measures what I have designated in the past as the "logarithmic average". A meter which measures the logarithmic average will not necessarily give the same result as one which measures the arithmetic average but the difference between the two types will in general be less than that between two arithmetic average meters that are set for overlapping times. The logarithmic average type has the advantage that if two or more are used on the same load the indication of all of them will be the same, therein differing from the arithmetic average or block interval type. The possibility of controversies arising between the buyer and the seller of electric service is thereby avoided if the logarithmic type of demand meter is used instead of the block interval type.

The thermal storage type of demand meter which I suggested nearly fifteen years ago (see Character of the Thermal Storage Demand Meter—A. I. E. E. Transactions, Vol. XXXVII, page 189) indicates the logarithmic type of average and consequently possesses the advantages of that type which are set forth. The thermal storage type of demand meter had no sale in the U. S. until about 1927 or 1928, although it was introduced into Canada in 1918 and at once came into general favor and by 1926 or 1927 was in almost universal use in Canada. After the general adoption of the thermal type demand meter in Canada, it came into a limited use in the U. S. but it still constitutes an exceedingly small proportion of the demand meters used in the United States.

The demand meter recently announced by a prominent electrical company (See A New Demand Meter, by B. H. Smith, in Electrical Engineering for January 1934, page 94) has the advantage of indicating the logarithmic average and therefore avoids the disadvantages of the arithmetic average type. It has the disadvantage of being more complicated than the thermal type, but this disadvantage is probably not sufficient to offset its advantage in its correct principle of operation. If the maximum demand method of selling electric service is to continue, it is my prediction that the inherent inaccuracy of the block interval method of measurement will eventually be recognized and that both the buyers and the sellers of such service will insist upon the adoption of a method of measurement which is capable of reasonable accuracy. The existing "Code for Electricity Meters" specifies that the errors of meters for the purpose of measuring energy shall not exceed 1% to 5% depending on load, power factor, voltage, etc. I submit that it is illogical to insist on this comparatively high degree of accuracy for the measurement of energy when the measurement of maximum demand is subject to a theoretical error of 100% and to an actual error that tests have shown occasionally reaches 15% and quite often exceeds 5%.

The degree to which the indefiniteness of the block interval method of demand measurement affects the amount that must be paid for electric service depends not only on the load factor of that service, but also upon the particular rate form used. Unfortunately, there is still a very considerable variation in the manner in which the information given by a maximum demand meter is used. In general it may be said that the proportion of the average bill for electric service that depends on the indication of the maximum demand meter (where such meters are used) lies somewhere between 15% and 50% of the total bill rendered. The remainder of the bill depends on the indications of watthour or energy meters. There is probably no measuring device in general use today which has a higher degree of accuracy than the usual watthour meter, so that the larger proportion of the amounts that are paid for electric service are based on measurements as accurate as can be obtained. But this does not prevent some 15% to 50% (depending on load conditions and rate form) of the bill for service being subjected to an indefinite error that occasionally mounts to 15% and is quite often above 5% if the block interval type of demand meter is used to determine the maximum demand—as is almost universally the pres-

ent practice in the United States. As soon as the buyers and sellers of electric service begin to realize the existence of this indefinite error, it is my opinion that they will insist upon the use of a more accurate method for the measurement of maximum demand. It is fortunate that such more accurate methods exist in the thermal storage device and also in the recently announced demand meter.

If the maximum demand method of purchase and sale of electrical service is to persist, it is my opinion that the use of these more accurate methods of maximum demand measurement will eventually supersede the older block interval meters. However, a long study of the problem of the most equitable methods of selling electric service has led me to question whether or not the maximum demand principle is the most equitable. I would like to take this occasion to propose for consideration a method for the sale of electric service which departs quite radically from any of the rate forms now in use. It is quite proper that my suggestion should be made to the Association of Iron and Steel Electrical Engineers since my suggestion is intended to apply particularly to loads which are extremely variable, and I believe I am correct in stating that a steel mill load is as variable, both in amount and rapidity, as any which an electric power plant may be called upon to handle.

Let us begin our consideration by stating a principle which in my opinion should be the ideal goal to be achieved in all sales of electric service, viz. that the amount which any user of electric service pays for that service should be proportional to the cost of rendering that service. I am perfectly willing to admit at the beginning of my discussion that this ideal is at present impossible of complete achievement. There are many factors that affect the cost of electric service and no method for the sale of electric service can recognize all of them. One of the most important of these factors is the **load factor.** Others are power factor, diversity factor, time of occurrence of the maximum demand, etc. This suggestion is aimed at the question of load factor only.

Maximum demand was introduced into rate schedules for electric service some twenty-five years ago, for the purpose of taking into consideration the variations in the costs of electric service with variations in load factor. It is my opinion that the usually accepted form of rate schedule does not recognize load factor to a sufficient extent. I have taken the published rate schedule of a large Eastern power company and calculated the power bill for three different load factors, 20%, 50% and 80%. The rate schedule selected is typical and represents with a fair degree of accuracy the variation in power bill that may be expected in the normal rate schedule that applies to the great majority of companies that sell electric service. I have assumed a maximum demand in each case of 1000 kw. and have assumed a 30 day month (720 hours). These calculations show the following results:

Load Factor	Dollars per month. Total	Cents per kw.hr.	Dollars per kw. of demand per month
20%	$3080.00	2.14c	$3.08
50%	$4385.00	1.22c	4.38
80%	$5681.00	.985c	5.68

It is my opinion that this tabulation shows either that the high load factor user is paying too much for his service or that the low load factor user is not paying enough. In other words, it is my opinion that the typical form of rate schedule now in general use does not recognize load factor to a sufficient degree. I base this opinion on the proposition that between 50% and 75% of the **cost** of serving a given user depends on the fixed charges (interest, depreciation, taxes and insurance) on the plant necessary to serve him and that in turn the capacity of the plant to serve him depends on his maximum demand and not upon the amount of energy used. Referring to the specific example cited above, if $5.68 per kw. of maximum demand per month represents a true measure of the cost when the load factor is 80%, $3.08 will not cover the cost when the load factor drops to 20%. Or to state the same idea in the reverse way, if $3.08 per kw. maximum demand per month is a true measure of the cost of service when one load factor is 20%, the cost does not rise to $5.68 when the load factor rises to 80%. In other words, the weight given to load factor in most existing rate schedules is insufficient. In this connection it should be pointed out that if maximum demand is measured by block interval type demand meters, the possibility of error in the determination of maximum demand does not justify giving larger weight to load factor than is given by existing rate schedules. Increased recognition of load factor in rate schedules must therefore await a more general adoption of a more accurate method of measuring maximum demand than is now in general use in the United States.

I have raised the question above as to the advisability of retaining the maximum demand principle in our rate schedules. By this I do not mean that load factor should not be taken into account in our rate schedules. My contention is that load factor should not only be taken into account but that it should have considerably increased weight above that given to it by the usual existing form of rate schedule. There are methods of recognizing load factor other than those now generally in use and I would like to propose for consideration another such method. What I have in mind can best be indicated by a specific example. Let us therefore assume that a user of electric service has a typical daily load curve such as is shown in Fig. 1. The load factor of this load is approximately 50% based on the maximum 30 minute use of that particular day. However, if we take into consideration that Saturday and Sunday loads, which presumably are much lower than shown by Fig. 1, and further that the maximum use during the maximum day of the billing period might be much higher than shown in Fig. 1, the load factor might drop considerably below 50%. The largest indeterminate factor in fixing load factor is the amount by which the maximum 30 minute use during the billing period departs from the 30 minute use of the typical day shown in Fig. 1. The shape of the load curve during no two days is exactly duplicated. It depends on the time of year, state of business, character of load use and many other factors. The method for selling electric service which I would propose for consideration depends upon the principle of excess kw. hours. What I mean by this term may be illustrated by reference to Fig. 1. If we analyze this figure we will find that the kw. hours used on

this particular day that are in excess of 1000 kw. are approximately 1.5% of the total kw. hours taken on that day, and those above 900 kw. are approximately 7.0% of the day's total. If the total kw. hours are sold at one rate per kw. hour and those in excess of a given value of kw. at considerably higher rate, we would have the excess method of selling electric service which I would propose for consideration. A user's total bill for electric service would, under this suggestion, consist of three parts, viz.

X kw. at a dollars per kw. per month.
y kw. hours (total kw. hours used) at b cents per kw. hour.
Z kw. hours (excess kw. hours above X kw.) at c cents per kw. hour.

An anlysis of this form of rate for electric service readily shows that there is some value of kw. (X in the above tabulation) that will give a minimum bill. This value will depend on the relative values that are assigned to "a", "b" and "c" in the above tabulation as well as to the user's load factor. It would be my idea further that a user would obligate himself by contract extending over a term of years to pay for the "X" kw. of the above tabulation, whether used or not, and that he would be free to increase the kw. contracted for but not to decrease it at any

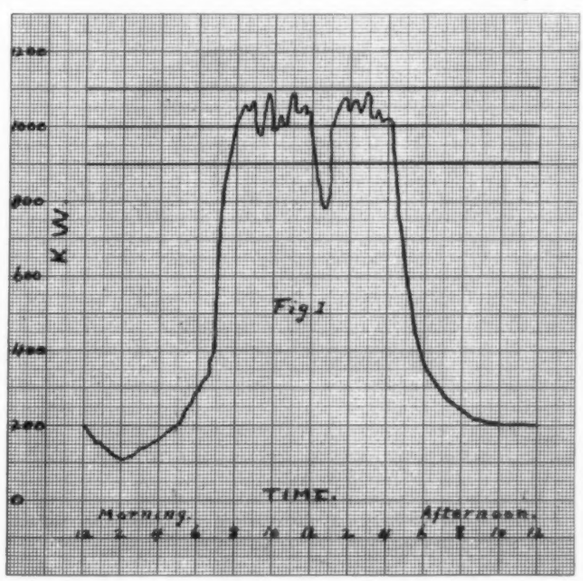


FIG. 1

time within the contract period. This provision would be only fair to the supplier of the service since he must hold himself in readiness at all times to supply not only the contracted amount ("X" kw.) but also such excess as the user may draw at the higher or "c" rate. This method of selling service recognizes load factor as do the existing forms of rate schedules based on demand, but does so in quite a different manner. The weight given to load factor is under complete control by adjusting the values that are assigned to "a", "b" and "c". Let us take the load curve shown in Fig. 1 and see first how a user may adjust his own contract terms to obtain a minimum bill. For the purposes of this illustration let us assume a 30 day month, that the load curve of Fig. 1 is duplicated every day of the month, that the maximum 30 minute use of the day is 1080 kw., that the load factor is 50%, that the kw. hours above 1000 kw. amount to 1.5% of the total and that the kw. hours above 900 kw. amount to 7.0% of the total. Under these assumptions, the total kw. hours per month are 388,800, the excess kw. hours above 1000 kw. are 5832 and those above 900 kw. are 27216. Let us assume further that the rates assigned to "a", "b" and "c" are $3.00 per kw. per month of contract amount, .2c per kw. hour for total kw. hours and 5c per kw. hour for excess. If the user's contract is for 900 kw. his monthly statement would be as follows:

900 kw. at $3.00	=	$2700.00
388800 kw. hours at $.002	=	777.60
27216 kw. hours at 0.05	=	1360.80
Total		$4838.40

If now the user were willing to increase his obligated contract amount to 1000 kw., his monthly statement would be as follows:

1000 kw. at $3.00	=	$3000.00
388800 kw. hours at $.002	=	777.60
5832 kw. hours at $.05	=	291.60
Total		$4069.20

Thus, the user, by obligating himself to a higher contract rate can make a very material reduction in his monthly power bill. By increasing his contract obligation still further, a further small reduction could be secured. Whether or not it would be wise for the user to do so would depend entirely on his ability to control his load factor. In other words, the rate form proposed would place the responsibility for control of load factor directly on the user—where it belongs—and would give incentive for high load factor. The degree of this incentive may be controlled by the supplier by assignment of the "a", "b" and "c" rates. In other words, the weight given to load factor is under the control of the supplier.

If in addition to the recognition given to load factor by the above suggested form of rate schedule, the supplier wishes to recognize the actual maximum demand, this could be done in a number of obvious ways. One way, often used in existing rate schedules, is to limit the contract obligation for the kw. that the user pays for to a given fraction, usually 75%, of the highest previous maximum demand indicated by his demand meter. This prevents the user being unduly penalized by some freak condition of load that might give an unexpectedly high peak load for perhaps only once during the billing period. But if such recognition is to be given to the maximum demand of the billing period, I submit that the maximum demand should be indicated by some metering device which is not subject to the inherent errors of the usually used block interval demand meter.

To the objection that there is no existing method of measuring excess kw. hours, I am obliged to admit that this is true, but it is true simply because there has been no demand for such a device. The standard forms of integrating watthour meters may readily be modified to register excess kw. hours as well as total. This may be accomplished by inserting a differential gear and constant speed motor between the rotating meter disc and the gear train of any standard type of watthour meter. The idea is old and nothing new is claimed for it. It has

never been used simply because there has been no demand for such an instrument. Manufacturers do not make and offer for sale devices for which there is no demand or for which, by advertising, they cannot create a demand. This is the status of the excess meter. Also, by a comparatively simple modification, the thermal demand meter may be made to register not only excess kw. hours but total kw. hours as well. If, therefore, the idea of the sale of electric service on the basis of excess kw. hours appeals to buyers and sellers of such service, the demand for devices to give the necessary information can easily be supplied.

It is only proper that my suggestion for a modification of the usual form of rate schedule should be made to such a group as the Association of Iron and Steel Electrical Engineers. There are at least a few steel manufacturing or fabricating companies that buy their power requirements from public utility companies, so that some of you gentlemen will find yourselves in the position of advisers on the terms of the contracts for the purchase of such power. If you are purchasing on the basis of a maximum demand that is measured by a block interval meter, let me suggest that you confirm other tests that have been made on the indefiniteness of this type of meter by installing at least two on your load, so adjusted that their time periods "break joints", and thus determine for yourselves the degree of indefiniteness for your particular load. With this information at hand, the supplying company may logically be approached with a suggestion for a modification of contract form. It has always been my experience that public utility companies are anxious to be completely fair to their customers and no difficulty should be experienced in arriving at a satisfactory agreement. If a modification of contract form is made, let me suggest at least a consideration of the form that is outlined above.

It is only proper to call attention to the availability of the excess principle for the sale of electric service to all types of electric service; it is by no means confined to steel mill loads. It seems to me that it is particularly applicable to domestic loads. There are now quite a large number of rate forms for domestic service that endeavor to recognize load factor after some fashion. None of these rate forms, so far as I know, recognize load factor by measurement of demand. It is mostly recognized by some method of estimating the demand or possible demand of the user, such as floor area or number of rooms or number of outlets or the capacity of all current using devices, etc. etc. The resulting rate form is undoubtedly preferable to a flat rate but it still leaves much to be desired. The excess principle applied to the domestic load leaves the householder free to take service in any amount at any time, but at the same time puts the desired premium on high load factor. It also insures a definite and fixed income from each householder. The application of the excess principle to domestic loads is certainly worthy of careful consideration.

Summary

1. Meters used for the purpose of determing the amount which a user of electric service shall pay for that service, should be above suspicion as to accuracy in so far as it is humanly possible to make them. For this reason, the block interval type of demand meter now in almost universal use in the U. S. is unsuitable due to its large factor of indefiniteness. This indefiniteness may be avoided by the use of other types of demand meters.

2. Load factor, to determine which demand meters are used, is of prime importance in determing cost of service and should be recognized to even a higher degree than in most existing rate schedules.

3. In the case of domestic loads, the recognition of load factor on the basis of some measured quantity instead of an estimated quantity, as is now almost universal practice, would be preferable.

4. The recognition of load factor by the method of measuring excess kw. hours is suggested for consideration.

Discussion

Discussion Presented by

J. F. Gillespie, Asst. Elec. Supt., Carnegie Steel Company, Ohio Works, Youngstown, Ohio.
Paul M. Lincoln, Director, School of Electrical Engineering, Cornell University, Ithaca, N. Y.
A. G. Montgomery, Engineer, American Steel & Wire Company, Cleveland, Ohio.
Dr. J. Slepian, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.
G. A. Hughes, Electrical Engineer, Truscon Steel Company, Youngstown, Ohio.

J. F. Gillespie: Mr. Lincoln remarked that two meters giving the load by the arithmetical method do not always read the same. I was wondering whether each individual meter in two tests would always read high or would one sometimes read high and the other low.

Paul M. Lincoln: It is purely a matter of chance. Let me illustrate. Suppose you are buying power on 30 minute basis and you get a peak load just 30 minutes long. If the demand meter happens to start a demand period at the beginning of this block of load the entire block will be registered; if, however, the meter happens to start in the middle of the block, only one-half will be registered. So it is purely a matter of chance how much of your peak that meter is going to read. You can't tell which type is going to read the higher. It depends where measurement starts and ends.

A. G. Montgomery: Does anybody have any advantage in this country over those in Canada that use the logarithmic type? Or, vice versa?

Paul M. Lincoln: Now as to the comparison between the two types of demand meters-block interval or logarithmic, which will read the higher? That is your question really. I can't answer it because the block interval is a matter of chance. The block interval may be higher, but it will probably be lower

in general than the logarithmic average, because the drafts of power usually occur during comparatively short intervals, and in general I should say that the logarithmic average type will read somewhat higher than the block intervals, although I can't make this a general statement.

Dr. J. Slepian: Isn't there a correspondence between the maximum reading of the logarithmic average meter and the maximum temperature of the machine of a given size applying that load? It seems to me there should be a definite relationship.

Paul M. Lincoln: The law which governs the heating of electrical equipment under load is of the same nature as that which governs the response of a thermal demand meter—i. e., an exponential law. In general, however, the time of response to heating in electrical equipment is greater than the usual times employed in demand metering. In my opinion, it would be perfectly logical to increase the standard times for demand metering from 15 to 30 minutes now usually in use to 30 to 60 minutes.

G. A. Hughes: I would like to ask one question. There has been considerable discussion, for instance, on spot welder loads and loads requiring a short interval of time, stating that the slow acceleration of meter disk in the watt hour meter does not accurately record all the energy. On the other hand, is the statement that slow deceleration compensates the slow acceleration. I noticed that this integrating watt hour meter was one of the most accurate devices possible for human intelligence to make. I assume that the watt hour meter will accurately record all the energy passing through.

Paul M. Lincoln: Failure to accelerate with rapidly increasing loads should be, and I believe is, offset by failure to decelerate with rapidly decreasing loads.

G. T. Hollett, Steam & Combustion Engineer, Illinois Steel Company, and prominent active member of the A. I. & S. E. E., died December 3, 1934.

Sketching Mr. Hollett's career it is found that it

G. T. HOLLETT

was closely confined to the Steel and Allied Industries. Graduating from Purdue in 1910 with a degree in mechanical engineering, and after a special apprenticeship course with the Westinghouse Machine Company, he served as steam engineer in charge of all power plants for the Baltimore and Ohio Railroad, Pittsburgh Division, from 1912 to 1914. From 1914 to 1918 he was chief engineer of the Indiana Reformatory in charge of the operation and maintenance of all equipment. He then entered the services of the Illinois Steel Company, in the steam engineering department, where he worked until late in 1920. He then became affiliated with the By-Products Coke Corporation, now a part of the Interlake Iron Corporation, up to 1925 when he became identified with the Youngstown Sheet & Tube Company at the Indiana Harbor Works. In December 1927 he returned to the Illinois Steel Company where he remained until his death.

During the six years Mr. Hollett belonged to the A. I. & S. E. E. he took a very active interest in all its functions. This is substantiated by a glance through the proceedings of the Association where may be found the many comprehensive papers and discussions he contributed to the technical files of the society. As well as offering his support to the Association in this way, he also served as a member of the Board of Directors in the year 1931-1932, belonged to the various committees of the Combustion Engineering Division, and at the time of his death was chairman of the gas utilization section of this division.

The A. I. & S. E. E. feel that they have lost a loyal member and wish at this time to express its sympathy to his family, as well as his associates and many friends.

Developments In The Rolling of Sheets and Strip 1934

By STEPHEN BADLAM,
Consulting Engineer, Pittsburgh, Pa.

Paper presented at the A. I. & S. E. E. Annual Convention held in Cleveland, Ohio, September 18, 19 and 20, 1934.

Introductory

Approximately a year ago, at the meeting of this Association in Pittsburgh, the author presented a paper on "Recent Developments in the Rolling of Sheets and Strip",* the purpose of which was to outline the developments in the art of Flat Steel Rolling up to that time.

The present discussion is intended to supplement that paper by describing briefly some of the major developments that have taken place between the date of that paper and the present.

In general, the situation a year ago was marked by activity in the construction of mills for the cold rolling of strip, in widths from 36" to 76", with no new construction of mills for the hot rolling of strip under way. The present period is marked by activity in the construction of mills for the hot rolling of strip, with consideration of the equipment for cold rolling principally as supplementary to the hot mills.

STEPHEN BADLAM

In order to give the proper perspective, even at the risk of repeating that with which you are familiar, a brief resume of the art of flat steel rolling would seem not out of place.

Early Mills

For very many years, at least since the early 1890's, the possibility of rolling sheet like material, by methods that would be an improvement over those of the conventional sheet mill, had been considered, and two proposals had actually reached the stage of construction and operation. These were: the Teplitz Mill built about 1892, at Teplitz, Bohemia, in Europe, and the two Bray Mills, built in 1902, at Pittsburgh, Pa., and in 1905, at South Sharon, Pa., respectively. The Teplitz Mill operated for a period of about 15 years and was abandoned in 1908, while the Bray Mills were operated over a period of about seven years, and the second mill was abandoned in 1910.

The Interim

In 1910 both the Teplitz Mill and the Bray Mills had passed into the discard, and the field was again held supreme by conventional type of hand sheet, or tin plate mill. This continued to be the case for a period of thirteen years, or until the advent of the Ashland Mill, in 1923.

The Ashland Mill

During the latter part of the period of supremacy of the conventional sheet mill, the American Rolling Mill Co., with plants at Middletown, and Zanesville, Ohio, had been conducting experiments with the object of determining the fundamentals of sheet rolling, and had developed a plan for the continuous, or rather tandem, rolling of sheets. The purchase by this company of the properties of the Ashland Iron & Mining Co., at Ashland, Ky., in 1921, presented the opportunity for turning these plans into actuality.

It was proposed to build a sheet mill which would take a 10,000 lb. ingot, and without allowing it to become cold, to reduce to 16 gage, and heavier, sheets, of the usual widths and lengths, and after reheating, to further reduce to 22 gage, and heavier. Construction was commenced early in 1923, and the first sheet was rolled in January, 1924.

The Strip Mill

During the period just considered, from 1890 to

* Published in the December, 1933, issue of the Iron and Steel Engineer.

1923, another development was taking place that was to have a profound influence on the production of all flat rolled material. This was the strip method of rolling, by which we mean the production of flat material, thin in proportion to its width, in long lengths, from a heavy slab. During this period the strip mill had been gradually increasing its range, from a few inches in width, in 1890, until, in 1926, strip was being produced, in widths up to 24", in gages of No. 12, and heavier, and narrower in lighter gages.

Paralleling the development of the hot strip mill, the cold strip mill had been gradually increased in width capacity, and was producing cold rolled strip in widths up to 24", in 24 gage and heavier, and in lighter gages in narrower widths.

The Butler Mill

In 1926, with the construction of the mill of the Columbia Steel Co., at Butler, Pa., the field of the strip mill was increased at a single step, to 36", both in the hot rolled and in the cold rolled product, or, in brief, the methods of strip rolling were translated into sheet widths.

This product, in widths over 24", has been defined as Broad Strip, and the mills for producing it, as Broad Strip Mills.

The development of the broad strip mill, since 1926 may be considered as taking place in three stages.

First Phase 1926-1927

The first phase, in 1926 and 1927, was that of pioneering. The first mill, that of the Columbia Steel Company, at Butler, Pa., was designed and built in 1926, and started operation on November 25, of the same year.

The next three mills, those of the Trumbull Steel Company, the Weirton Steel Co., and the American Sheet & Tin Plate Co., were all authorized, the engineering work done, and construction work started, in the same year, before the Butler mill went into actual operation. This was a unique situation in the history of the rolling mill art, as never to my knowledge at least, has a radically new development been seized upon in this manner, before being tried out in practice.

Of these three mills, two, the Trumbull and the American Sheet & Tin Plate Co. mills, were of practically the same width capacity as the Butler mill, 30" to 36". The third, the Weirton mill, went beyond, to 48" or nearly the maximum width obtainable, at the time, in sheets. The three mills went into operation in 1927, the Trumbull mill on June 15, the Weirton mill on August 10, and the American Sheet & Tin Plate mill on November 3.

The Trumbull mill was made by revamping an existing wide strip mill, width capacity 22", while the other two were entirely new, from the ground up.

Second Phase, 1928-1930

The second phase, 1928 to 1930, was one of broadening the field. The American Rolling Mill Co., which in the meantime had purchased the Columbia Steel Co., building a mill at the Middletown, Ohio, plant, having a capacity of 66" wide, in the heavier, plate gages, and 52" in the lighter, strip or sheet gages. The Middletown mill went into operation August 8, 1928.

In the following year, on January 7, 1929, the Wheeling Steel Corporation mill, at Steubenville, O., went into operation with a width capacity of 54", in all gages down to about No. 12, and lighter gages, in reduced widths.

The third mill in this period, that of the Great Lakes Steel Corporation, which went into operation in September, 1930, was of comparatively narrow width capacity, 32", but embodied a number of technical advances, which permitted a further increase in the range of width and gage produced.

Third Phase, 1931-2

The third phase, in 1931 and 1932, saw a great increase in the number of mills, of the broad strip type, as well as an increase in their range of width and gage, with four new mills constructed.

The first of the four to go into operation, that of the Illinois Steel Co., in November, 1931, was marked by a great increase in the width capacity, 84", but at a sacrifice in the minimum gage, about ⅛" only.

The next two mills, the Otis Steel Co. mill, which started operation in January of 1932, and the Inland Steel Co. mill, which went into operation in March of the same year, presented a combination of wide width and light gage, the former mill having a width capacity of 66", and the latter of 69", in gages No. 12 and heavier, and correspondingly lighter gages in reduced widths.

A fourth mill to go into operation during the period, that of the Allegheny Steel Co., first operated in April, 1932, while of the same type, was designed primarily for breakdowns in widths up to 32", of 12 gage and heavier, for further reduction to sheets, on hot mills of the conventional or semi-automatic type.

Engineering Features

The broad strip mills built up to, and including, 1932, show a wide variation in their engineering features. The original Butler Mill comprised a two-high, reversing, universal rougher in which the slab was given a number of passes before going to the four stand, four high continuous finisher. This was the only mill of this type built to date. All the other mills consisted of a roughing train, of several stands, in each of which the piece is given a single pass, before going to the continuous four high finishing train.

It is in the roughing train that we find the greatest variation in the arrangement. No two mills are alike, or similar, as regards the spacing of the stands, the speeds, the connected horsepower, or whether each stand is driven by a separate motor, or one motor drives 2, 3 or 4 stands.

The finishing train shows a closer approach to standardization, the principal difference being found in the number of stands, on close centers, in the last group. This figure ranges from 3 to 6.

The advantage of maximum weight coils apparently was not considered in the earlier mills, and few, if any, were able to produce light gage coils of a weight that would today be considered desirable for cold rolling purposes.

1932 may be considered as marking the culmination of this period of technical development, and the desirability of the type, from the standpoint of high production, high quality of product, and low operating cost, had been definitely answered in the affirmative.

Whether we will enter a second period of technical development, and what form and objective it may take, is as yet unknown.

No new construction of hot mills of the broad strip type was undertaken during the years 1932 and 1933, but in 1934 orders were placed for three new mills.

One for the Ford Motor Company, at Dearborn, Mich.; another for the Youngstown Sheet & Tube Co., at the Campbell Works, Youngstown, O.; and a third for the Carnegie Steel Co., at the McDonald Mills, McDonald, O.

Work is also under way for the remodeling of the 28" wide strip mill, at the Gary Works of the Illinois Steel Co., and a further remodeling of the 96" continuous plate mill, at the South Chicago Works of the same company, is under consideration. In the former case the present two high finishing stands are to be replaced by a lesser number of four high stands, enabling it to produce wider and thinner strip. In the latter case, an additional stand of four high rolls is contemplated, to enable the mill to produce comparatively light gage strip, 12 gage and under, in widths up to about 90", and in coils.

There is also reported as under consideration, although no authorization has been announced, five additional broad strip mills. One for either the Buffalo, or the Sparrows Point Plant of the Bethlehem Steel Company, one for the Great Lakes Steel Corporation, one for the Republic Steel Corporation, and two for the Carnegie Steel Company.

Ford Motor Company
Dearborn, Mich.
56" Broad Strip Mill

The Ford Motor Company had, since 1925, operated an integrated steel works, at the River Rouge Plant, where they produced a part of their steel requirements, consisting of forging billets, bars, shapes, and narrow strips, but had purchased all of their sheets and wide strip requirements from outside sources of supply.

Early in the present year it was decided to enlarge their range of production to include sheets and wide strip, and orders were placed for a new blooming mill, and a continuous broad strip mill, having a capacity of producing strip in gages as light as No. 18, up to 48" wide.

Both the blooming mill and the hot strip mill, with their auxiliary machinery, are being designed and built by the United Engineering and Foundry Company, who also have charge of all general engineering work in connection with the foundations, buildings and electrical equipment.

The general arrangement of the blooming and hot strip mill is shown on the sketch Fig. 1.

By reference to this sketch, it will be noted that the blooming mill, and the hot strip mill, lie parallel to each other, but operate in opposite directions. This arrangement has many advantages, among which is a decided economy in space, and the possibility of installing all main drive motors, with their auxiliary equipment, in a single motor room.

Blooming Mill

The new 44" blooming mill is placed in line with the existing 42" and 32" continuous blooming mills, and will not only supply slabs to the hot strip mill, but may also furnish large blooms to the old blooming mill, replacing the small ingots now used for reduction to billets for the bar mills.

The location of the ingot stripper and an ingenious arrangement of the ingot cars, at the soaking pits, permits the charging of ingots into the pits with a minimum loss of time, so that the greater part of the initial heat of the ingot is conserved. Double ingot cars are provided, one for the delivery of the ingots from the stripper to the pits, the other for the delivery from the pits to the ingot approach table.

The new blooming mill is of the two high, reversing type with rolls 38" in diameter x 96" long, and

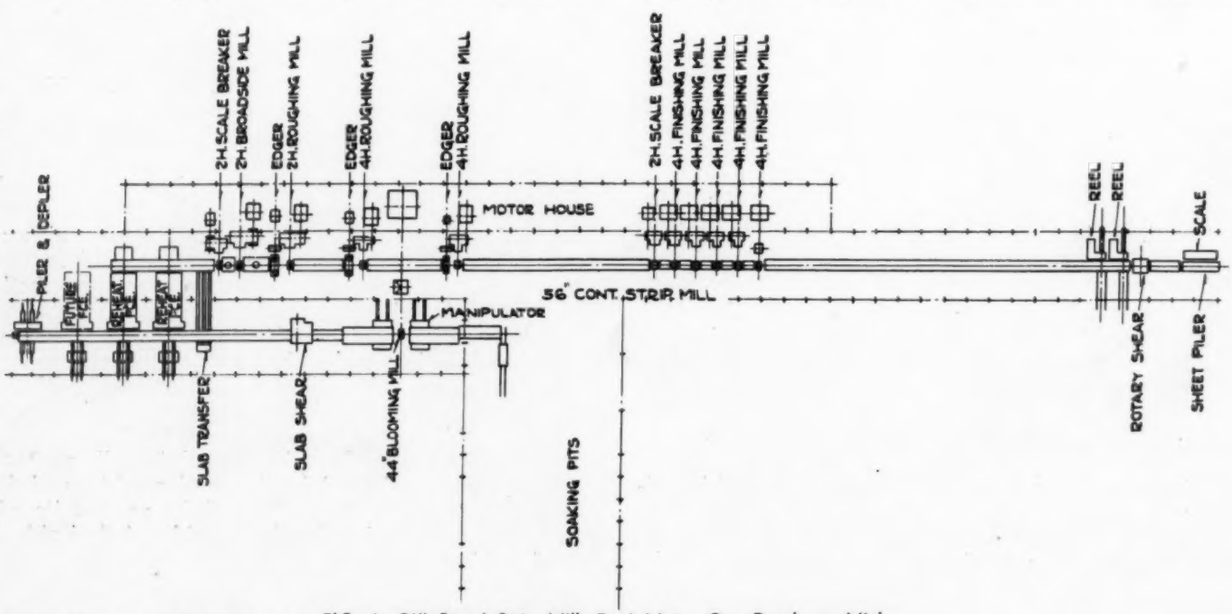


FIG. 1—56" Broad Strip Mill, Ford Motor Co., Dearborn, Mich.

is driven by a 7000 HP, 50/120 RPM, 750 V., DC motor, through a stand of 44" P.D. 66" long, double helical cut pinions. Power is supplied by a flywheel motor generator set directly connected to the 13,200 volt power line.

Ingot Manipulator

The manipulator is of the "United" overhead, double rack type, with fingers mounted on one side guard, on the entry side, for turning over the slabs, and setting them up for edging. Each side guard is operated by two forged steel rams, through rack and pinions, driven by four roller bearing mounted, double helical gear drives, the tilting fingers being operated by a separate drive of like construction. All drives are mounted on the foundation on the drive side of the mill, and are entirely clear of the mill tables.

Screwdown

The screwdown is of the enclosed type, driven by two motors through a roller bearing mounted, double helical, cut tooth gear drive, and so designed that the inertia of the moving parts has been kept to a minimum, thereby securing a maximum acceleration, and consequent reduction in the time required to set the rolls for the edging passes.

Mill Tables

The front and back tables are reversing, and each table is driven by two, enclosed type, roller bearing mounted, double helical gear drives, each drive being driven by a separate motor. These drives are so located that the shock load, on the line shaft is evenly distributed over its entire length. All rollers, and the line shaft, are mounted in roller bearings, and the gearing is forged steel, with heat treated, cut teeth. The line shaft on these tables, as well as all other tables in the installation, is entirely enclosed and sealed against the entrance of water, or of mill scale, and the leakage of oil.

Scale Disposal

Provisions have been made for the removal of mill scale by the installation of a pan type, chain conveyor, under the mill and tables, which carries all scale to a conveniently located hopper car.

Slab Shear

From the blooming mill the slab is conveyed by roller tables, equipped with motor operated side guards for squaring the slab for cutting, to the 1000 ton slab shear, where it is cropped and cut to lengths. Special equipment has been provided at the shear which removes the crop ends from the table and delivers them direct to open hearth charging boxes.

The shear has a capacity to cut 7"x49" hot steel. The throwout clutch is motor operated, and the gage head is motor traversed and fitted with a self relieving device which moves the gage head away from the cut piece on lifting.

From the shear the cut slabs are conveyed to the slab transfer for direct rolling, to the slab furnaces for reheating, or may be carried down the furnace approach table to a slab piler and depiler, for storage.

Slab Transfer

A reversing slab transfer is installed between the slab reheating furnaces and the mill for the conveyance of slabs from the blooming mill line to the hot strip mill line, when reheating is not required. It may also be used for the storage of slabs which may be returned to the blooming mill line as required, and for returning the slabs to the charging side, in emergencies, when it is required to empty the furnaces of hot steel.

Slab Furnaces

The two slab reheating furnaces installed are of the Rust Engineering Company design, and of the most modern type. It may be of interest to note that one of these furnaces is equipped with a tile recuperator, while the other is equipped with a carborundum, tubular type, recuperator.

Provisions have been made for the installation of a third furnace, at a future date.

Hot Strip Mill
Roughing Train

On discharge from the slab reheating furnaces, or from the slab transfer, to the furnace delivery table, the slab is carried to a two high, 24"x56" scale breaker stand, where it is given a comparatively light reduction, which serves to break up the scale, which is then removed by a high pressure water spray.

A scale conveyor, similar to that at the blooming mill, is provided to handle the scale from the furnace delivery table and the scale breaker.

Following the scale breaker stand is a two high, 42"x96" broadsiding stand. In this stand the piece may pass straight through, with the usual reduction, or a 7'-6" long slab may be turned through 90°, by means of a turntable, on the entry side, and then passed through the stand, broadside, and spread to the desired width. By means of a second turntable, on the delivery side, it is turned back to its original direction, for the succeeding passes.

The entry and delivery tables are equipped with motor operated, adjustable side guards for squaring up the slab for entry into the rolls, and on the entry side a pusher is provided which insures the proper entry of the slab into the rolls.

Following the broadside stand is a second two high, 32"x56" stand, and two four high, 21" and 46"x56" stands, with the necessary tables, guides, etc., in which the slab is reduced to a thickness of from ½" to 1", depending upon the gage desired for the finished strip. In order to control the width of the strip and to produce the required rolling effect on its edges, each of these last three stands is preceded by a vertical edger. All roughing stands are spaced apart sufficiently so the slab is never in more than a single stand at the same time.

The strip leaves the last roughing stand at a speed of approximately 420 ft. per minute, and is entered into the first stand of the finishing train at about 150 feet per minute. This difference in speed makes it necessary that the piece be entirely out of

the roughing train before it enters the finishing train, therefore a table approximately 175 feet long is installed between the two trains, and means are provided on the table to control the temperature of the metal so that the entire strip enters the finishing scale breaker at approximately the same temperature.

Finishing Train

The finishing train comprises a two high, 24"x56" scale breaker stand, similar in size and design to that installed in the roughing train, and also used for cracking the scale, and five four high, 21" and 46"x56" roll stands with the necessary motor operated side guards, entry and delivery guides, and air operated up-loopers.

Between the last two four high stands a specially designed device is installed which automatically controls the tension of the strip at this point.

Runout Table

As the strip leaves the last finishing train roll stand, at a speed of approximately 1500 feet per minute, it is conveyed by an individually motor driven roller table a distance of approximately 300 feet where it is either cut into lengths by a flying shear, and delivered to a piler, or entered into one of two hot coilers, where the strip is formed into a tight coil and discharged to a conveyor, and thence either as a sheet or a coil, taken to the pickling department for further processing.

Provision is made for the installation, at some future time, of a double hot bed, about 250 feet long, in connection with the individually motor driven, hot run table.

Gear Drives

All drives on the roughing and finishing stands, with the exception of the last finishing stand, on which the motor is direct connected to the pinion stand, are provided with reduction gear drives which are of the combination gear and pinion type, which results not only in considerable saving in space, but adds greatly to the rigidity of the various units.

All mill and edger drives are fully enclosed, all shafts mounted in roller bearings, and all gears cut with Sykes Precision helical teeth. All mill drives, and where possible all auxiliary equipment, is arranged for forced feed lubrication from central stations.

Roll Changing

Provisions have been made for the rapid changing of rolls in all mill stands by the installation of roll changing machinery, which permits of the withdrawal of the entire roll and bearing assembly, as a unit, from the roll housings.

Electric Motors

In the roughing train the gear drive for the first scale breaker is driven by an 800 H.P. induction motor, with flywheel, the broadside mill by a 2500 H.P. slip ring induction motor, with flywheel, and the three following stands by 2500 H.P. synchronous motors, without flywheels. The four 2500 H.P., A.C. motors receive current at 13,200 volts, direct from the power station.

The three vertical edgers are driven by D.C. adjustable speed, 230 volt motors, the first two of 600 H.P. each, and the third of 150 H.P.

All stands of the finishing train are driven by D.C. adjustable speed motors, the scale breaker by a 400 H.P., the next four by motors of 3000 H.P. each, and the last finishing stand by a 2500 H.P. motor.

The finishing stands are supplied with power by six 1500 K.W., 275 volt, motor generator sets, connected in pairs, in series, to furnish current at 550 volts. The vertical edgers and the mill auxiliary motors are furnished current from six additional, similar motor-generator sets, at 250 volts.

Youngstown Sheet & Tube Co.
Campbell, Ohio
79" Broad Strip Mill

The Youngstown Sheet & Tube Co., for several yaers, has had under consideration the construction of a broad strip mill, and was, in fact, one of the earliest licensees for the method. Early in June of the present year authorization was given to proceed with the construction of the mill, at the Campbell Plant, where it will take the place of a continuous sheet bar mill, and a skelp mill, and will permit of the abandonment of the older of two blooming mills.

The new continuous strip mill will have rolls of 79" face, and is designed to produce light plates and skelp, from ¼" to ½" in thickness, and hot rolled, (blue annealed) sheets, 12 gage and heavier, up to 72" in width. In addition it will produce hot rolled, and hot rolled annealed, sheets in the lighter gages, from No. 13 to No. 18, in somewhat reduced widths.

The estimated annual capacity will be between 400,000 and 500,000 tons of hot rolled products, dependent upon the average width and gage.

In general the design of the mill will be the same as that of the Inland Steel Co. mill, with such changes as the operation of the latter mill had indicated as desirable. The mill is being designed and constructed by the Mesta Machine Co., who had also built the Inland mill.

The general arrangement of the new hot strip mill, and its relation to the existing, No. 2 blooming mill is shown in the sketch, Fig. 2.

Blooming Mill

The new hot strip mill of the Youngstown Sheet & Tube Co. will be supplied with slabs from the present No. 2 blooming mill. No. 1 blooming mill and its pit furnaces will be dismantled to permit of the new construction.

The heating capacity of No. 2 blooming mill will be increased. Of the present eight rows of four hole pits, two rows will be dismantled, and replaced by seven holes of one way fired pits, built by the Surface Combustion Co., and one gas fired, circular pit, designed by the Youngstown Sheet & Tube Co., and built by the Electric Furnace Co., Salem, O.

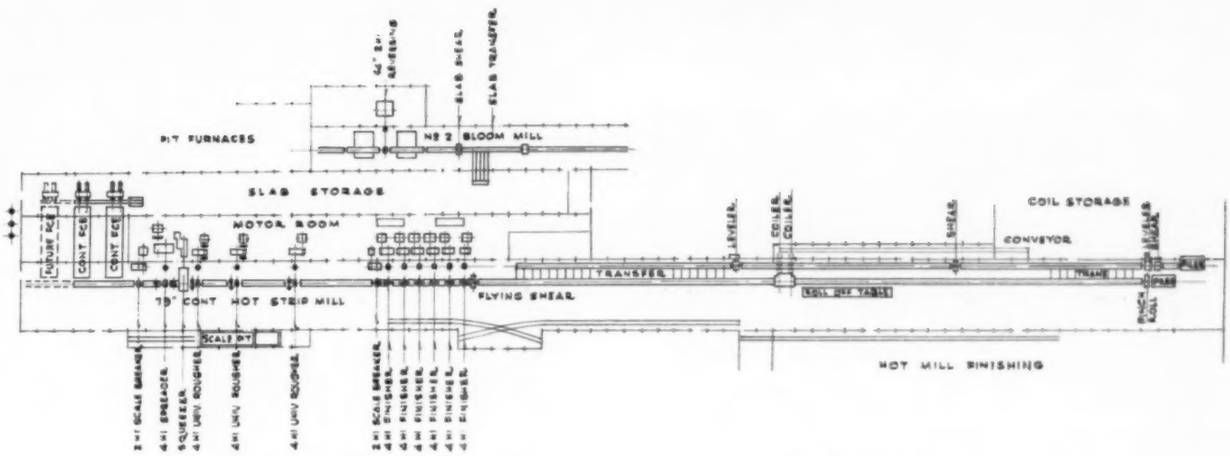


FIG. 2—79" Broad strip mill, Youngstown Sheet & Tube Co., Campbell, Ohio.

Buildings

The buildings housing the new strip mill, and its accessories, include:

Slab Storage.
Motor Room.
Hot Mill Building.
Hot Coiling and Shearing Building.
Coil Storage Building.
Hot Mill Finishing Building.

Furnaces

Two slab heating furnaces, designed and built by the Surface Combustion Co. are provided, with room for a third, should such later be desired.

Roll Train

The roll train is, as mentioned above, substantially identical in design with that of the Inland Steel Co., and comprises two groups of roll stands, a roughing and a finishing, separated by a considerable space, about 100 feet.

Roughing Train

The roughing train includes a two high scale breaker, having rolls 24"x79", a four high spreading stand, having rolls 36" and 49"x96", and three four high universal stands, having rolls 24" and 49"x79", and with vertical rolls on the entering side.

Between the scale breaker and the spreading stand there is a turntable for turning the slab through 90°, when cross rolling is desired, and a pusher for entering the slab squarely into the rolls. Between the spreader and the following stand, there is a second turntable, for returning the spread slab to its original direction, and a hydraulic squeezer for squaring up the edges and ensuring that all slabs are the required width.

All stands of the roughing are so spaced that the piece is never in more than a single stand at the one time.

Finishing Train

The finishing train comprises a two high scale breaker, and six stands of four high rolls, 24" and 49"x79". Between each pair of stands loopers are provided, operated electrically.

Flying Shear

Immediately following the last stand of the finishing train, and as close to it as possible, there is located a rotary flying shear, for cutting material, hot, direct from the mill. Cut lengths leaving the flying shear are carried by the hot run out some 700 feet to a pinch roller and bar piler, for loading, or for further processing if required.

Hot Transfer

Some 50 feet beyond the flying shear there is a 258 foot lateral transfer, by means of which the heavier gages may be transferred to a parallel roller line, having a plate leveler, and end shear, and at the far end a second leveler, flying shear, and bar piler. Just before the last leveler there is a second lateral transfer by means of which heavy material may be returned to the hot run out line, and carried back towards the mill to a roll off table whence it may be piled on the floor for cooling, and for further processing.

Hot Coiler

At the lower end of the first transfer table there are two hot coilers, in conjunction with which is a cooling conveyer for delivering the coils to the coil storage building.

Electric Motors

The roughing train is driven throughout, with the exception of the vertical edgers, by A.C. constant speed induction motors. The first scale breaker is driven by a 1500 H.P., 270 R.P.M. motor, the spreading stand by 3000 H.P., 150 R.P.M., and next two following stands by 3000 H.P., 514 R.P.M. motors.

The fourth and last roughing stand is driven by a 5000 H.P., 514 R.P.M. motor. Each of the three vertical edgers is driven by a 150 H.P. adjustable speed, D.C. motor.

The finishing scale breaker is driven by a 500 H.P. and the six finishing stands by 3500 H.P. motors each. All are D.C. adjustable speed, the power for which is supplied by two 6000 KW. motor-generator sets.

General Characteristics

The Ford Mill and the Youngstown Sheet & Tube Mill, and we may include with them the Inland Mill, show a decided approach to standardization in arrangement and design.

Furnaces

Each of the three mills is provided with furnaces capable of handling slabs of 15 feet in length, in a single row, and of 7 feet 6 inches in length, in a double row. The thickness may range from 3" to 6". The 15 foot slab, when of 3½" thickness, will give a finished coil of a weight of 2000 lbs. per foot of width, or heavier coils with a thicker slab. The shorter, 7 foot 6 inch slabs, will permit of broadsiding in a stand of 96" roll length.

Roll Train

Each of the mills comprises two groups of roll stands, a roughing and a finishing, separated by a considerable space. This space as well as that from stand to stand of the roughing, is sufficient so that, with the maximum weight of slab, the piece is never in more than a single stand at the one time, until after it has entered the finishing train. In the case of the Ford Mill, the space between the roughing and finishing trains is approximately 175 feet, or double the usual length of the piece at this point, and means are provided for controlling the temperature prior to entering the finishing train.

Roughing

The roughing train comprises, in each case, a two high scale breaker stand, a spreading or broadsiding stand, of a width considerably greater than that of the succeeding stands, 96" in all cases. In this stand the slab may pass straight through, with a reduction of the usual amount, or a 7½ foot slab may be turned through 90°, by means of a turntable, and then passed through the stand, broadside, and spread to the desired width. By means of a second turntable, on the delivery side, it may be returned to its original direction for the succeeding passes. In front of the spreader stand a pusher is provided for entering the slab squarely in the rolls.

Following the spreader stand are three reducing stands, each preceded by a vertical edger. In the case of the Ford Mill the edgers are separate from the following flat stand, whereas in the other two mills, they are of the universal type, integral with the flat stand. In the two wider mills all stands, except the scale breakers, are of the four high type, while in the narrower mill the first two are two high, and the third and fourth, four high.

Finishing

The finishing train, in all cases, consists of a two high scale breaker followed, in the one case by five, and in the other two by six, stands of four high rolls. In the former case provision is made for the addition of a sixth stand, should such later be found desirable. The finishing stands are placed on the closest centers practicable, this generally being determined by the dimensional requirements of the motors and gear reductions.

Motor Drive

The main motor drives consist of a separate motor for each stand. For the roughing, the Inland mill is provided with four motors of 3000 H.P. induction type, provided with flywheels, and the Youngstown mill with three similar motors with flywheels and one 5000 H.P. motor without flywheel. The Ford mill is provided with four motors of 2500 H.P. each, the first, spreading stand, only being of the induction type, with flywheel, and the remaining three of the synchronous type, without flywheels.

The finishing stands, in the two wider mills, are each driven by D.C. adjustable speed motors, of 3500 H.P. each, while the narrower mill is driven by 3000 H.P. motors on the first four stands, and a 2500 H.P. motor on the last stand.

In all cases the total connected H.P. figures very close to 500 H.P. per inch of roll face.

All stands of all mills, drive through gear reductions with the single exception of the last finishing stand of the Ford mill, which is direct connected. The Inland and Youngstown mills have separate gear reductions and pinion stands, while the Ford mill has combined units.

All edging stands of the Inland and Youngstown mills are driven by 150 H.P. motors, while the first two edgers of the Ford mill are driven by 600 H.P., and the third by a 150 H.P. motor.

Carnegie Steel Co.
McDonald, Ohio
42" Broad Strip Mill

The third of the mills to be placed on order during the present year is that of the Carnegie Steel Co., for the McDonald Mills, McDonald, Ohio.

The order for this mill was placed early in November with the United Engineering & Foundry Co., and the mill is expected to go into operation during the third quarter of 1935.

The mill is expected to comprise ten stands of horizontal rolls, two high and four high, two vertical edgers, and two horizontal scale breakers.

The mill is designed to roll 16 gage to 38" wide and 18 gage to 24" wide. The estimated annual capacity is approximately 400,000 tons.

In addition to the mill proper there will be provided complete facilities for cutting to length, slitting, flattening and oiling, and for annealing and pickling cut lengths.

The Steckel Hot Mill

During the year past there have been two hot mills, of the Steckel type, under construction, and

the original mill, which had been used by the Cold Metal Process Co., at Youngstown, O., for experimental and development purposes since 1932, has been rebuilt, and placed in commercial operation.

As is probably known to most of those interested, a paper† on the subject having been presented to this Association last year, the Steckel hot mill consists essentially of a reversing mill, the rolls of which are driven, in which a heavy slab is reduced by successive passes, to a thickness at which it may be hot coiled, and then is passed onto a reel, enclosed in a heating chamber, first on one side of the rolls, and then on the other, until the piece is reduced to the desired gage.

It will be seen that by this method, a much thinner strip, and in a longer length, may be produced, than would be the case if it were permitted to run out on the tables between the later passes, when the metal is thin, and the rate of cooling high.

Of the Steckel hot mills mentioned, one will be set up in tandem with a 42" two high universal mill, in which the slab will be broken down to plate thickness before passing to the Steckel mill. This division of the work between the two stands will not only greatly simplify the operation, and will increase the tonnage, but also, on account of the roughing work being taken off the finishing stand, will permit of a better finish to the strip, and a very substantial increase in the life of the rolls, and a corresponding reduction in the roll cost.

The other two mills will be of the single stand type, in which all the work, from the slab to the finished strip, will be accomplished in a single stand of rolls.

McClouth Steel Company
Detroit, Mich.

The smaller mill of the Steckel type, for the McClouth Steel Co., Detroit, Mich., has recently been started.

This mill consists of a single stand, two high reversing mill, with rolls 21½" diameter by 20" face, equipped with roller bearings, and driven by a reversing motor of 1500 H.P. It is equipped with two hot coilers, enclosed in heating chambers, one on each side of the mill.

This mill is intended for the production of hot strip, both for sale as such, and as stock for cold rolling, in the usual gages, in widths up to 12", and in coils up to 3000 lbs. in weight. The estimated monthly production is set at 4000 tons.

Cold Rolling

As already mentioned, the dominant activities during 1933 were in the line of cold rolling equipment for broad strip and particularly strip for tinning.

Of the mills under way, or recently completed, at that time, the two 42" wide mills at the Gary Tin Mills, and the two 84" wide mills at the Gary Sheet Mills, of the American Sheet & Tin Plate Co., are now in operation, both satisfactorily, and in the case of the tin mills, with results that have even exceeded expectations.

The similar mills, of the Republic Steel Corporation, Warren, O., the Youngstown Sheet & Tube Co., Indiana Harbor, Ind., and the Jones & Laughlin Steel Co., Aliquippa, Pa., are also in regular operation.

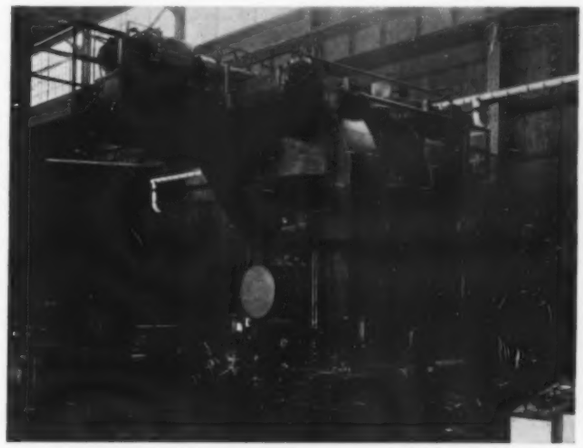


FIG. 3—16" & 49"x42" 4-hi Reversing cold strip mill

The Inland Steel Company has placed in operation the five stand tandem cold mill, and the two skin rolling mills, for the production of tin plate, which with the Steckel mill will give them an estimated production of about 10,000 tons per month. A description of this mill appeared in the Iron & Steel Engineer for February, 1934.

The Wheeling Steel Corporation, at Yorkville, O., had completed and placed in operation a new five stand tandem, cold strip mill, and a single stand, skin rolling mill. The tandem train is driven by five 800 H.P., D.C. adjustable speed motors. In connection with the installation of the new mills there has been a rearrangement, and extension, of the previously existing facilities.

The Eastern Rolling Mill Co., Baltimore, Md., has purchased and placed in operation, a four high cold mill, with rolls 16"-44"x84", for cold rolling sheets in short lengths, particularly to meet the demands of the automotive industry for full finished auto-body sheets processed in this manner. The mill is driven by a D.C. adjustable speed motor of 400 H.P., 250/750 R.P.M. This mill went into operation in April of the present year.

The Weirton Steel Company, has also built, and placed in operation, a four stand tandem cold mill, with rolls 18"-42"x38", to be used for the production of wide thin strip. Each of the four stands is driven by a 600 H.P., D.C. adjustable speed motor and the reel by a 150 H.P. motor.

Ford Motor Company,
Dearborn, Mich.
Cold Strip Mill.

Supplementing the hot strip mill, now under construction, the Ford Motor Company is also installing a 56" 3 stand tandem, cold strip mill, for the production of full finished sheets, in widths up to 48", in the gages demanded for auto-body work, and for other sheets in gages lighter than may be produced on the hot strip mill.

Each of the stands of the tandem mill will have four high rolls, similar in every way to those of the

† Published in the January 1933 issue of Iron and Steel Engineer.

hot strip mill, and each will be driven by a 1250 H.P., D.C. adjustable speed motor. Following the last stand is a reel driven by a 400 H.P. motor. Both mill and reel motors will be furnished with power from two 1500 KW, motor generator sets, arranged in series for 550 Volts.

In addition to the 56" tandem cold strip mill, there has been ordered an 84" wide single mill, likewise of the four high type, and capable of producing auto-body sheets up to 78" wide.

Youngstown Sheet & Tube Co.
Campbell, Ohio
Cold Strip Mill

The continuous hot strip mill of the Youngstown Sheet & Tube Co., is designed to produce plates, strip, and sheets of No. 18 gage and heavier. In order to round out the capacity in the lighter gages, a cold rolled strip mill is now under construction, for the production of cold rolled, (full finished) sheets, in the usual gages, up to 84" in width.

Hot rolled stock for the cold strip mill will be produced in coils, and in addition, sheet breakdowns from 3/16" to No. 16 gage, may be produced for finishing, on the existing three high and two high hot sheet mills, hot rolled annealed, (black) sheets in gages from No. 26 up to the lower limit produced on the hot strip mill.

The new cold strip mill will comprise: a tandem train of three stands of rolls of 75" face, followed by a reel; two single stands of four high rolls, one stand of 75" face equipped with a reel, for rolling coils, and the other stand, of 90" face, without a reel, for rolling short sheet lengths. In addition there will be a single stand of two high rolls, of 54" face, equipped with a reel, for skin rolling coils.

It is expected that all ordinary widths and gages will be produced, from the hot strip, in one pass through each of the stands of the tandem train, following which the coils may be annealed, and skin rolled in coils on the single mills with reels, and then edge trimmed, and cut to length. If desired the coils from the tandem train may be leveled, cut to length, annealed, and skin rolled in short lengths on the single mill without a reel.

The tandem train, with the single stand with reel, will be capable of producing full finished auto-body sheets, as well as less highly finished grades of cold rolled sheets, up to 69" in width, and the single stand without reel, up to 84" in width.

The estimated annual capacity of the cold mill installation is estimated at from 150,000 to 250,000 tons dependent upon the average width and gage.

Cold Strip Mills

In the field of production of cold rolled strip, 24" wide and under, there has been considerable activity, approximately 10 mills of the backing roll type, equipped with anti-friction bearings, being completed, or under construction, during the year past. These mills are divided between the standard driven roll type, and the Steckel type.

One outstanding feature of the last year has been the very considerable number of two high cold mills to be equipped with anti-friction bearings, these mills range from one with rolls 4"x4" up to one with rolls 28"x84".

Of the standard type of backing roll mill, one has been ordered by the Greer Steel Co., Dover, O., having rolls 12"-28"x30", this being a duplicate of a mill purchased last year. In connection with this a two high, skin roll mill, with rolls 20"x28", has been ordered, equipped with anti-friction bearings.

The Rotary Electric Steel Co., Detroit, Mich., have ordered one stand of four high rolls, 11½"-25"x16", and two stands of two high, with rolls 12"x10", likewise equipped with roller bearings.

Two smaller four high mills are under construction, one with rolls 5¼"-16"x12", for the Newman-Crosby Co., Pawtucket, R. I., and one with rolls 4½"-9½"x8", by the Thompson Wire Co., Mattapan, (Boston) Mass.

The Steckel Mill

The use of the Steckel cold mill, especially for the production of the thinner gages, and for specialties such as high carbon steel, stainless steel, etc., has shown a steady advance during the past several years.

The Allegheny Steel Company now has five of these mills in operation at the plant of the West Leechburg Steel Co., one of 26", one of 20", and three of 7½" face, primarily for the production of stainless steel.

The Weirton Steel Co., at Weirton, W. Va., has three in operation, one of 38", one of 28", and one of 20" face, used principally for the production of soft steel, in light gages.

The Crucible Steel Company of America has two in operation and a third on order, all of 7½" face, and used for the production of high carbon and stainless steels.

The Signode Steel Strapping Co., also has two in operation, all of 7½" face, and used for rolling thin gage soft steel for box bands and strapping.

Numerous other companies have one or two Steckel mills used for various purposes, both for ferrous and for non-ferrous materials, in this country and abroad.

The total number of mills now in operation is approximately 40.

Three mills of the Steckel type have been purchased during the past year, one each by the Crucible Steel Co., Pittsburgh, Pa., and the Edison Storage Battery Co., East Orange, N. J. Both these mills are of the smaller size, with rolls of 7½" face. The first is for use in rolling high carbon and stainless steels, and the other for ordinary low carbon steel. The third mill, of the 18" size, has been purchased by the Elliot Brothers Co., New Castle, Pa.

Three High Water Mills

The mills of the three high, water mill, type that are in operation, have been giving an increasingly good account of themselves, particularly as roughers for finishing to lighter gages, on the conventional and semi-automatic mills of the two high type, and for both roughing and finishing full finished sheets, 22 gage and heavier.

While there has been no new construction of mills of this type reported, for use in the United States,

some four mills are under construction for export. One is being built by the Mackintosh Hemphill Co. for India, and one each by the Lewis Foundry & Machine Co., for Australia, Canada and Japan. The latter mill will have rolls 68" in length, and will be complete with tables, motors and control. It will be driven by a 500 H.P. motor, and have a capacity, in No. 16 gage, of approximately 70 tons in 8 hours.

Of the four mills under construction, three are designed for the production of breakdowns, and one for finishing full finished sheets.

Tata Iron & Steel Co. Three High Water Mill

The accompanying photograph, Fig. 4, illustrates one of the latest mills of the three high water mill type. This mill was built by the Mackintosh-Hemphill Co. for the Tata Iron and Steel Co., India.

The mill with its tables, electric control, etc., was designed by, and in collaboration between, Mr. Frank

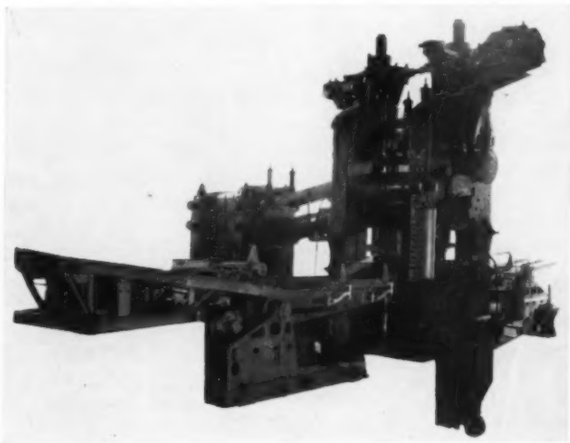


FIG. 4

L. Estep, Vice President, Perin Engineering Co., the Mackintosh-Hemphill Co., the Wean Engineering Co., and the Clark Controller Co., the latter two companies furnishing the tables and electric control equipment, respectively.

It will be noted from the illustration that this mill is of the balanced top roll type, with the top roll driven through a three high pinion stand. This construction is considered desirable when the mill is to be used as a roughing mill for comparatively heavy sheet bars. The rolls are 33"x52", top and bottom, and 20"x52" middle. The top roll is spring balanced and the middle roll floating, with air balance controlled by the operation of the catcher table.

The screwdown is tied in electrically with the continuous furnace operation, and the mill tables in such a way that, by pressing a button, the mill is set for each pass, and the furnace and table on the entering side is set for automatic operation. The catchers table is made semi-automatic, entailing an operator, investigation having shown that faster operation may be secured in this manner than by fully automatic operation.

This mill, on 16 gage breakdowns, using 12"x-37½"x16½ lb. sheet bars, and operating on a sixteen second cycle, with two single and three matched passes from pair to pair, would produce at the rate of about 10 gross tons of bars per hour.

The illustration shows the top roll in a raised position. This will permit of changing the middle roll without stopping the train, and is particularly desirable when, as in this case, the three high mill is hooked up to the same motor, and gear reduction, that drives other sheet mills.

The middle roll is equipped with roller bearings, and when changing the roll, the entire roll and bearing assembly is removed, and replaced, at the one time. Both top and bottom rolls are equipped with bearings of the synthetic resin type with water lubrication.

The Conventional Sheet Mill

In the field of the conventional sheet mill, of the two high type, as far as the United States is concerned, there has been no additional capacity built, other than as provided for existing mills, by the addition of continuous pair and pack furnaces, automatic feeder and catcher tables, and other means for the mechanical handling of the material in process.

There has, however, been built in this country, one tin mill, of the conventional type for Japan, as well as a single stand, two high sheet mill, for India, the latter to be used as a finisher for a three high rougher.

Roll Neck Bearings

The use of anti-friction roll neck bearings has shown a continued expansion during the past year, not only as applied to the backing rolls of four high mills, but also to two high mills, the latter use being accelerated by the application of small O.D. roller bearings, of the "Quill" type, which have rendered it possible to retain the usual ratio of roll neck to body diameter.

One of the largest single orders for anti-friction bearings ever placed is that of the United Engineering & Foundry Co., for the Ford mills, for bearings for seven stands of hot rolls, with spares, as well as for pinions, gear reductions, table rollers, screwdowns, and accessories. Bearings for four stands of cold rolls have also been ordered for the same company.

Expansion in the use of bearings of the oil film type, (sleeve bearings finished to an extreme degree of precision) has continued, with some 125 bearings, in 32 stands of rolls, in 10 different mills now in use. Some four or more stands of four high hot mills have now been equipped with bearings of this type, and some twelve stands of four high cold mills, included in which is one five stand tandem train completely so equipped. It is creditably reported that in one new mill, now under construction, all stands both of the hot mill and the cold mill may be equipped with bearings of this type.

There have been several applications to hot mills of the three high type, and a very considerable number to two high mills.

Bearings of the synthetic resin type are coming into extended use, with highly satisfactory results, in two high mills, ranging from wire rod mills to a

44" slabbing mill, and including conventional sheet mills, and in three high water mills.

Conclusion

In conclusion, it may be said, to use a military term, that the year past has been occupied in "a consolidation of the position" gained in the several preceding years.

Technically there has been no outstanding new development brought to the public notice, but rather an extension and refinement, of the earlier developments.

For the present improvements are to be looked for in the direction of meeting increasingly rigid specifications for quality, in physical characteristics, gage tolerance and surface, and in improvements in the economy of operation, principally in those items of cost other than pure rolling.

The great problem that is still left to the future for solution, is that of producing sheets, or strip, in auto-body gages, up to somewhere in the vicinity of 100" wide. Whether this will be done in a long strip, by means of rolls of that length, and corresponding motor horspower, or whether a narrower strip will be rolled, to be later spread to the desired width, is something that the industry would be glad to have light upon.

The demand is becoming audible, that it will be met is, I believe, more than probable, how it is to be accomplished we have yet to learn.

ITEMS OF INTEREST

Chester Hamilton Lehman has been appointed vice president in charge of sales of Blaw-Knox Company, Pittsburgh. Previously he was sales manager and secretary, and dates his active affiliation with the company since 1909, or during the major part of the company's existence.

▲

F. L. Ebersole, formerly with Babcock & Wilcox Tube Company, Beaver Falls, Pa., recently was named master mechanic with the Kelly Axe & Tool Works, Charleston, W. Va., division of the American Fork & Hoe Company, Cleveland.

▲

A. J. Townsend, vice president and general manager of the Rotary Electric Steel Company, Detroit, who has been chief executive officer of the company since its inception, has resigned as general manager because of ill health. He will continue as vice president and a director, but during the time necessary to recuperate will confine his activities to those of an advisory and consulting capacity.

▲

H. H. Doehler, president of the Doehler Die Casting Company, announces that Charles Pack has rejoined the Doehler organization in the position of assistant to the president in charge of all research and development work.

▲

The Delta-Star Electric Company, Chicago, Ill., announce the following changes in the Philadelphia office: J. B. Harris, Jr., operating as Harris and Butler, 1308 Real Estate Trust Building, has allied himself with the Rumsey Electric Company, 1007 Arch street, and carries with him the Delta-Star Electric Company sales representation.

▲

Thomas T. Watson, who joined the metallurgical department of Lukens Steel Company, Coatesville, Pa., in August, 1931, has been appointed development and service metallurgist. He will be engaged principally in service and sales work in connection with Lukens Nickel-Clad Steel.

Mr. Watson was born in Scotland thirty-five years ago and graduated in 1923 from the Royal Technical College in Galsgow with the degree of Associate of the R. T. C. Until 1925 he was assistant metallurgist at David Colville & Sons, the largest iron and steel manufacturer in Scotland. He then became metallurgist at the Clyde Alloy Steel Company, serving there for two years under Dr. A. McCance, managing director. From 1927 to 1930 he was assistant metallurgist at Dorman Long & Company, one of the largest iron and steel manufacturers in England. He came to this country in 1930 and engaged as a consulting metallurgist in New York until he joined the Lukens organization in 1931.

▲

W. V. Emery, who for the past ten years has been with the Harnischfeger Corporation of Milwaukee, has just been transferred to the corporation's Detroit office, in charge of P. & H.-Hansen arc welder sales for that area.

▲

A. J. Wadhams, manager, development and research, The International Nickel Company, Inc., has announced the addition of Fred J. Walls to the development and research staff.

▲

On the evening of December 18 the executive staff and department heads of the Hyatt Roller Bearing Company gave a testimonial dinner to Charles S. Lockwood, an 83-year-old member of their forces. He has just completed 60 years of continuous service in the employ of John Wesley Hyatt's several enterprises, 42 years of which have been with the Hyatt Roller Bearing Company of Newark, N. J., since its inception. The dinner was held at the Newark Athletic Club, and among nearly a hundred of the Hyatt men present, several of them have been associated with the guest of honor for more than a quarter of a century.

Thomas J. Fleischer, district sales manager, Crouse Hinds Company, Philadelphia, Pa., after some months illness is now back at his position and rapidly recovering his former good health.

▲

WITH THE MANUFACTURERS

▲

The Electric Controller & Mfg. Company have been awarded contract for controllers, brakes and limit switches for the Auxiliary Drives on the new 44" Blooming Mill and 56" Continuous Hot Strip Mill now under construction for the Ford Motor Co., Detroit.

▲

The Heine Boiler Company, St. Louis, which has been in receivership since 1930, has now been reorganized as a subsidiary of Combustion Engineering Company, Inc., New York.

▲

Improper use of artificial light caused an occupational accident every 46 seconds and a fatal accident every hour in America last year, according to D. W. Atwater, of the Westinghouse Lamp Company, and general secretary of the Illuminating Engineering Society.

Of the 1,269,500 occupational accidents (person gainfully employed at time of accident) recorded for the entire United States last year, 15% were traceable to poor lighting, based on statistics of the National Safety Council. For such conditions to exist in 20th Century America may be regarded as neglect of available lighting facilities, since many of these accidents are preventable under even average lighting.

Employers in the entire nation paid a total of $550,000,000 for all occupational accidents in 1933, of which $420,000,000 represented wage losses, $40,000,000 the medical expense, and $90,000,000 the insurance costs. About $200,000,000 of this total sum could have been saved through the use of correct lighting, according to Mr. Atwater's estimate.

For every dollar paid out by insurance companies in compensation claims for occupational accidents, the employer must pay four dollars for hidden or indirect costs!

While carelessness can be blamed for some of these accidents, inadequate lighting is responsible for many others. Judging by the great reductions in accidents made in many industrial plants through the adoption of better lighting, it is safe to assume that a similar improvement awaits us in other industrial establishments. No matter what kind of work engages one's attention, the illumination, providing it is correctly installed and operated, can help immeasurably toward the curtailment of accidents.

Lighting can be the chief provocation of occupational accidents. If the light source is inadequate or produces blinding glare, it induces eye strain that causes a worker to misjudge and err. Workers must see well if they are to work safely.

The better light, better sight nation-wide activity in which the country's eye specialists are co-operating this year, is directed to the goal of educating everyone in the correct use of artificial light. In this manner will human eyes be aided to see better and contribute to safer working conditions.

▲

The Brown Instrument Company who have consolidated with the Minneapolis-Honeywell Regulator Company will continue as a separate company with its existing organization but as a subsidiary of Minneapolis -Honeywell Regulator Company. Richard P. Brown will continue as president of The Brown Instrument Company and will become an officer and director of Minneapolis-Honeywell Regulator Company.

The Brown Instrument Company sales and service facilities will be continued from the present main office and factory at Philadelphia and the district offices located throughout the country.

▲

Three-High Mills have been developed by the Lewis Foundry & Machine Company for the rolling of sheet and tin bar to breakdowns and for the finishing of all types of sheets including full finished sheets.

In the Three-High Mill are incorporated special control features of motor operated screwdown, top roll drive and balance for both top and middle roll together with manipulating tables for handling bars and matched pairs, all of which are electrically and automatically controlled.

The automatic screwdown which is now being furnished with Lewis Three-High Mills has duplex type control, providing very close regulation of the mechanism which governs the various pass settings.

At the present time several Lewis Three-High Mills are under construction for export to some of the largest foreign steel plants. Those which are complete with double motor operated screwdown are arranged for accurate adjustment of reduction on each pass and automatic balancing of top and middle rolls to prevent slapping of rolls when material enters.

▲

A new, exceptionally compact centrifugal compressor (turbo-blower), making use of a gearmotor, is introduced by Allis-Chalmers Mfg. Co. By using the gearmotor for speed increase, the blower can run at higher than motor speeds, thus reducing dimensions and improving performance. Pressures from .75 lb. G. to 3.0 lb. G. are developed, the volumetric capacities corresponding to motor outputs from 3 to 30 hp. The units have application for foundry cupola blowing, oil and gas fired furnaces, pneumatic conveying, agitation and aeration, and for similar moderately low pressure air or gas supply services.

▲

Granite City Steel Company has just placed in operation one of the latest type of Surface Combustion sheet normalizing furnaces having improved alloy shaft conveyor with internal bearings and Sur-Combustion's oil gasification firing system.

Youngstown Sheet and Tube Company has contracted for the construction of one three-hole and one four-hole battery of one way fired soaking pits by Surface Combustion Corporation. A new feature to be added is automatic temperature control.

The Roller-Smith Company, 233 Broadway, New York City, has just published new switchgear catalog No. 8.

The line includes simple control panels, open and enclosed dead front equipment; cubicles; metal-clad gear; switch houses and special equipments of many kinds. The Roller-Smith Company makes most of the component items such as instruments, indicating and graphic; circuit breakers, air and oil; relays and instrument and control switches.

▲

A new synchronous-motor-operated timer, Type CR7993, for automatically timing the power supply to resistance welders by controlling the contactor on the welder, is available from the General Electric Company. The new timer eliminates human inaccuracy and guesswork, is easily and accurately set for the time most suitable for the work at hand, and, once set, the time is unaffected by line-voltage variations or surges. When adjusted for welding two thicknesses of metal, the control will provide satisfactory welds when several thicknesses of metal are placed between the electrodes—no change in timer or welder setting being required.

The G-E CR7993 timer consists of a 1-rps. reversing synchronous motor operating a set of contacts which control the opening and closing of a welding contactor. In normal operation, with the welder idle, power is applied to the reverse winding of the timer motor. This causes rotation until a projection on the motor shaft closes the contact, hits the stop, and stalls the motor. This contact is in series with the line contactor operating coil and the initiating switch (control) on the welder. When it is desired to make a weld, the initiating switch is closed, energizing the contactor coil, closing the contactor and applying power to the welder. At the same time, power is shifted from the reverse to the forward winding of the timer synchronous motor. During forward rotation of the motor, the timer contact is held closed by a permanent magnet until a second projection on the motor shaft opens it and thereby opens the line contactor circuit and removes power from the welder. Thus the duration of current flow at the weld depends only on the setting of the timer and has no relation to the length of time the initiating switch is closed. Opening the latter switch allows the timer to reset automatically for the next weld. Resetting does not take place, however, until the completion of a weld, even if the initiating switch is closed but momentarily, because an interlock on the welder contactor holds the circuit for the duration of the weld.

Setting the timer to provide a given duration of welding current is accomplished by means of a graduated disk associated with the second projection on the timer motor shaft. A range of from 1/12 to 5/6 of a second in one-cycle steps (60 cycle supply) is thus available—a range suitable for all usual welding requirements. Longer welding times, up to five seconds, can be obtained by the use of a lower-speed timer motor.

The new timer is furnished in several different forms. In addition to the timer unit alone, combinations of the timer with single and double-pole large and small contactors are available, each form being enclosed in a suitable case with hinged cover.

A new line of weatherproof, dust-tight Type A Safety Switches in standard sizes from 30 amperes to 600 amperes capacity, is now being supplied by The Electric Controller & Mfg. Company, 2708 E. 79th Street, Cleveland, Ohio.

These switches use the same switch mechanism that is furnished with the standard EC&M safety switch which is of type A construction and should not be confused with the type C safety switches using lighter construction and which do not have safety interlocks.

These EC&M weatherproof safety switches are equipped with fully interlocked door, making it impossible to operate the switch with the door open, or to open the door with the switch closed. They are enclosed in a 10 gauge steel cabinet which has been rustproofed by bonderizing before the enamel is applied. A heavy sponge rubber gasket makes a tight seal between the door and cabinet.

Outstanding features of these safety switches are compactness—narrow width—light weight—semi-floating, double break V-blades, V-stationary contacts backed up with steel springs which guarantee full contact under heavy pressure.

▲

"What About Your Roofs?" is the title of a new brochure just published by Johns-Manville.

From a standpoint of protection to industrial and business buildings, the roof is the most vital part of the structure, and the new J-M booklet deals extensively with the important problems of construction and maintenance.

▲

AMERICAN IRON AND STEEL INSTITUTE NOTES

▲

Present-day demands require steel for so many uses—from skyscrapers to nail files—that modern steel mills are prepared to offer their 500 products in as many as 100,000 different sizes, shapes and finishes.

Products of the steel mills, according to Steel Facts, issued by the American Iron and Steel Institute, include everything from massive 15-ton ingots down to spring wire for wrist watches, and reveal steel as the universal metal, essential in hundreds of ways in the everyday life of everyone.

Among the unusual items listed are bobby pin wire, beer case nails, snake fishing steel, hair pin wire, hat pin wire, safety pin wire, overcoat axe bit steel, corset wire, hook and eye wire, and jail bar steel.

To satisfy consumer demand, even these products are made by the steel mills in many shapes and sizes. To suit all the ladies with bobbed hair, for instance, makers of bobby pins need bobby pin wire in two shapes, eight thicknesses, seven widths and with a choice of four finishes—untempered; tempered; tempered and polished; and tempered polished and colored.

Some other products are available in as many as several hundred different sizes and shapes, hot rolled specialty strip steel leading with 462 varieties.

Last year, the most important consumers of steel

(Please turn to page 514)

Certainly! You can get fuses that won't blow needlessly

There are three major reasons why fuses sometimes blow needlessly:—

1 Poorly designed fuses that cause the link to blow before it should.

2 Fuses with too short a time-lag that keep popping out.

3 Circuits that are too heavily loaded.

What BUSS Has Done About It.

Years of research and testing were spent to create the present BUSS fuse. It is the last word in a scientific design that practically eliminates any chance of needless blows from either poor contact or injury to the link.

To prevent fuses blowing on harmless overloads BUSS developed the famous Super-Lag principle.

The BUSS fuse case combined with the BUSS Super-Lag Link gives you a fuse that protects your equipment and at the same time helps to keep that equipment running.

What You Can Do About It

If you are troubled with needless blowing of fuses check over your circuits. See that they are not loaded too heavily and that they are properly fused.

Next—we suggest that you actually compare BUSS fuses with others. After that, we believe your own good judgment will make you discard any other fuse.

If you would like the BUSS fuse man to call and give you the complete story drop us a line.

What we mean by scientific design

On BUSS 70 to 600 ampere sizes it is impossible to renew the fuse improperly. There are only a few parts to be handled. There are no hinges, wings, screws or loose washers. The chance of poor contact is reduced to an absolute minimum.

Terminals are held together by a fibre bar. This makes it easy to renew fuse and protects link against twisting or injury that might cause it to blow before it should.

The fibre bar IS NOT USED to keep blades in line. Terminals are automatically brought in line by slots in the brass end rings. This means that even if fibre bar shrinks or swells or is accidentally broken it can never cause bad contact in a BUSS Fuse.

Bolts and nuts used to hold link to blades are Cadmium Plated and have extra fine threads. They won't rust and they won't vibrate loose like a coarse thread bolt.

BUSSMANN MANUFACTURING CO. · · ST. LOUIS, MO.

A Division of the McGraw Electric Company

THE **BUSS SUPER-LAG** FUSE

A. I. & S. E. E.—TWENTY-SEVEN YEARS OF ENGINEERING SERVICE TO THE IRON & STEEL INDUSTRY

were the automobile, container, building and railroad equipment industries, in the order named. This group used 53 per cent of all the finished steel produced. The automotive industry alone took 21 per cent. In order to meet the vast range of demands for its products, the steel industry has a plant investment of $4,848,010,935.

The proportion of the steel industry's gross sales income going to state and local tax collectors has more than doubled since 1930, according to estimates furnished to the American Iron and Steel Institute which appear in its publication Steel Facts.

While the annual average of steel sales during the three years from 1931 to 1933 declined 60 per cent from the annual average for the seven years of 1924 through 1930, state and local taxes were only 9 per cent less.

The industry has paid to state, cities and local governments approximately $856,000,000 in taxes in the past decade. The annual average for the first seven years of the decade was $88,000,000 or 2.7 per cent of average sales and for the last three years the annual average of these taxes was $80,000,000 for the industry, or 6.1 per cent of such sales.

Average sales by the steel industry are estimated at approximately $3,244,000,000 annually from 1924 through 1930, compared with $1,310,000,000 per year for 1931 through 1933.

▲

"THE OLD MILL CRANE"

She stumbles along with a heart-weary song
Her beams bowed with sadness and care:
Her girders down-sagging, a step sadly lagging;
Her load seems too heavy to bear.

With a grumble and snort and a slight list to port
She batters her way down the track;
Her brasses rat-tattle like bullets in battle;
It's a grind to get there and back.

Her hoist is a riddle—might stop in the middle;
Her ribs look naked and gaunt.
Her bridge goes a-quiver with shimmey and shiver:
Her trolley must run when it can't.

Still, she keeps working and groaning and jerking:
It seems that she never will quit.
In spite of her years and her rickety gears
She still keeps on doing her bit.

Though she's now old and gray,
She has earned her way.
We know she has seen better days.
The work she has done,
And the years she has run,
Have earned a full measure of praise.

Newcomers sneer and they laugh and leer,
"Why don't you tear that wreck down?"
But old-timers say, "We remember the day
"That old baby could sure go to town!"

A. A. McFarlane, Electrical Dept.,
Wheeling Steel Corporation,
Steubenville, Ohio.

OBITUARY

▲

The Blaw-Knox Company announces the death of Wayne Rawley, vice president and director of the company, at Miami Beach, Florida, Friday, November 16. He was in his 56th year. Mr. Rawley had been in poor health for a long period.

Previous to his association with the Blaw-Knox Company, Mr. Rawley was connected with the Carnegie Steel Company, the Cambria Steel Company and the Pencoyd Iron Works in an engineering capacity. From 1902 to 1912 he was associated with the Riter-Conley Manufacturing Company as manager of their Woods Run plant. In 1912 he was elected vice president of Blaw-Knox Company.

Mr. Rawley was also a director in the Hoboken Land Company, Union Steel Casting Company, Lewis Foundry & Machine Company, Pittsburgh Rolls Corporation and National Alloy Steel Company.

▲

ASSOCIATION NOTES

COMING MEETINGS AND PAPERS

PHILADELPHIA SECTION

L. F. Coffin, Chairman — **L. O. Morrow, Secretary**

Engineers' Club, 1317 Spruce Street
Dinner 6:00 P. M. — **Meeting 7:00 P. M.**
January 5, 1935

Symposium—"Photo-Electric Cell Applications," Walter C. Kennedy, Philadelphia, Pa.

During the afternoon the members and their guests are invited to visit the Franklin Museum and Fels Planetarium on the Parkway.

PITTSBURGH SECTION

H. G. R. Bennett, Chairman — **C. H. Hunt, Secretary**

Cardinal Room, William Penn Hotel
Saturday, 2:00 P. M.
January 12, 1935

"Electrical, Mechanical and Lubrication Maintenance in Connection with Electrical Overhead Traveling Cranes," by F. W. Cramer, Supt. of Electrical Construction, Republic Steel Corp., Youngstown, Ohio.

Discussion

"Bridges and Trolleys—Drums, Ropes, Sheaves, Equalizers and Blocks—Track Wheels, Bumpers and Rails—Bearings, Lubrication, Gears, Pinions and Shafting—Brakes, Motors, Controllers and Wiring."

"Improvements in Mill Type Cranes," by R. J. Harry, Sales Manager, Alliance Machine Company, Alliance, Ohio.

CLEVELAND SECTION

C. C. Wales, Chairman — **W. W. Spanagel, Secretary**

Cleveland Engineering Society Rooms
December 14, 1934

"Welding as Applied to the Steel Industry," by A. M. Candy, Welding Engineer, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

CHICAGO SECTION

C. J. Smith, Chairman — **A. J. Whitcomb, Secretary**

Electric Association, 20 North Wacker Drive
Dinner 6:30 P. M.
January 9, 1935

"Recent Developments in the Industrial Applications of Mercury Arc Rectifiers" by W. E. Gutzwiller, Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

BIRMINGHAM SECTION

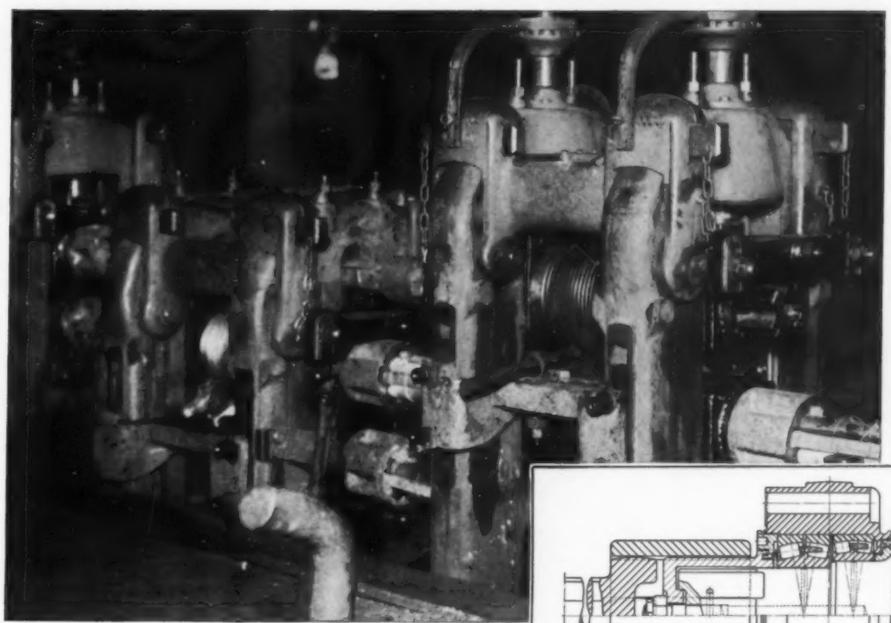
C. R. Tinsley, Chairman — **B. Thele, Secretary**

January Meeting
Details and Date Will be Announced Later.

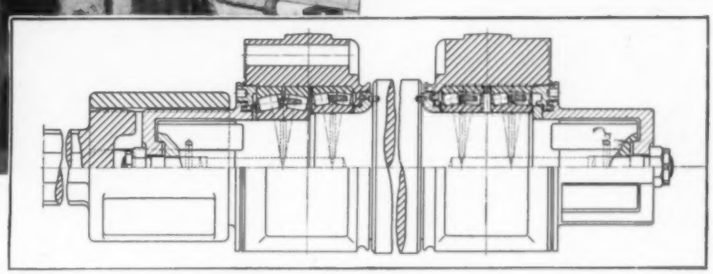
Modernize Mills By

CHANGE-OVER

To SKF Roll-Neck Bearings!



Five of 1050 SKF-equipped stands. Typical SKF installation on 11" rod mill train in operation at Nykroppa, Sweden. Application at right.



NEW MILL PERFORMANCE WHEN BEARINGS ARE SKF

IMPROVED TOLERANCES is but one important advantage obtained with SKF Self-Aligning Roll-Neck Bearings! There are power saving . . . steady operation . . . less scrap . . . rapid roll changes! Chocks and bearings are slipped on necks as a unit!

SKF Roll-Neck Bearings provide an equalized load distribution insuring the full bearing capacity and the longest life! And the mounting easily lends itself for adaptation to existing rolls! Achieve modern mill performance by running your old mills on SKF Bearings!

3319 SKF INDUSTRIES, INC., Front St. and Erie Ave., Phila., Pa.

Andrew Carnegie Used It In 1887

When—in 1887—Andrew Carnegie ordered a Universal Mill from Mackintosh-Hemphill, one ton was the average weight of ingot that could be used to make plates direct. Carnegie, not yet a Steel King, but possessed of the vision that was to make him one, wanted a great deal more.

He got it. Even after this mill had been in service *for 16 years* a commentator said, ". . . it now turns out 30,000 tons of steel slabs a month, and—as it has steadily increased its production from year to year—it seems probable that its limit has not been reached . . . ten to fifteen ton ingots are now rolled down to a thickness of 4 inches to 6 inches."

Impressive—but not surprising. Mackintosh-Hemphill (even then 68 years old) had made the first commercial Universal Mill in 1871, for the American Sheet and Boiler Plate Company. The Carnegie Universal was its twelfth. From first to last, it has averaged a Universal Mill every eighteen months, for 64 years, made nine out of every ten of these mills in the country.

Enriched by each succeeding year, the *experience* that made these achievements possible is still aiding industry. It is at your call—waiting to translate itself into new methods, new machinery for all departments of steel and non-ferrous processing and finishing. Your inquiry is invited.

MACKINTOSH HEMPHILL
PITTSBURGH

How M-H Experience Can Be Put to Work for You

Through certain special alloys, plus a unique wear-proofing process, Mackintosh-Hemphill can offer rolls that give better finish, more tonnage per dressing. May we tell you more about this M-H product?

Sealed

TO PRESERVE, we must SEAL . . . keep out destructive elements. New Departure Double N-D-Seal Ball Bearings keep out abrasive dirt and are *lubricated for life.* You should know more about the advantages of this important trend in bearing design — pioneered by New Departure. Ask for new booklet just off the press entitled, "Let's 'Can' the Oil Can!" . . . The New Departure Manufacturing Company, Bristol, Connecticut. Detroit, Chicago, San Francisco, London.

NEW DEPARTURE

N-D-SEAL

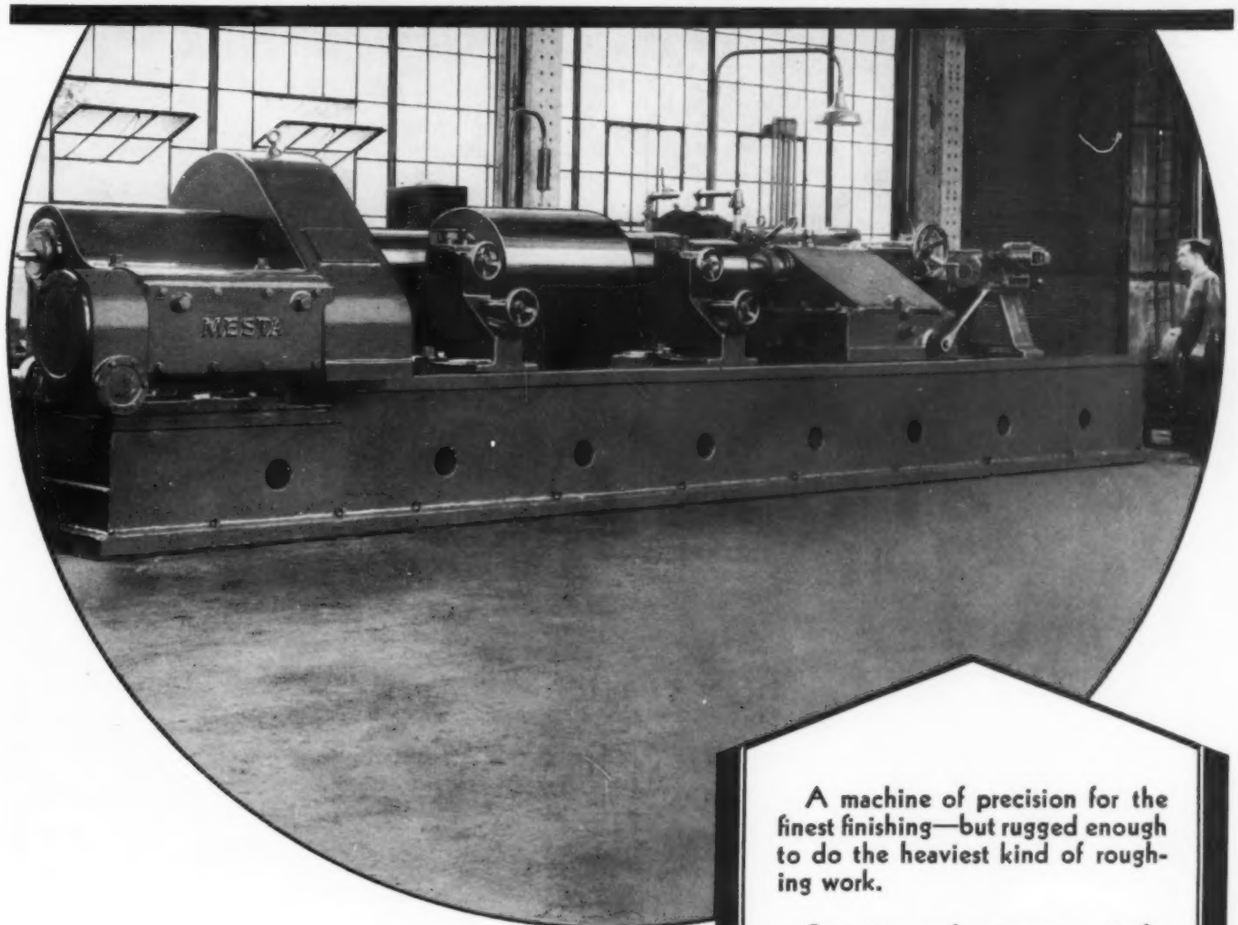
BALL BEARINGS

Isn't this
Horse Sense?

If the substitutes for "Tool Steel" gears were really "just as good but cheaper" — how could we stay in business?

A. I. & S. E. E.—TWENTY-SEVEN YEARS OF ENGINEERING SERVICE TO THE IRON & STEEL INDUSTRY

Mesta Roll Grinders



A machine of precision for the finest finishing—but rugged enough to do the heaviest kind of roughing work.

Crowning and concaving attachment an integral part of machine and guaranteed to produce any desired amount of crowning or concaving absolutely uniform and accurate.

Anti-friction bearings throughout.

MESTA MACHINE COMPANY
PITTSBURGH, PA.

A. I. & S. E. E.—TWENTY-SEVEN YEARS OF ENGINEERING SERVICE TO THE IRON & STEEL INDUSTRY

Specify Carnegie Rim-Toughened Crane Wheels for your new equipment. Use them for replacements on your present equipment. Their extra strength sets a new standard of crane wheel service. • •

CARNEGIE CRANE WHEELS

278

Product of **CARNEGIE STEEL COMPANY** • *Subsidiary of United States Steel Corporation* • **PITTSBURGH, PA.**

A. I. & S. E. E.—TWENTY-SEVEN YEARS OF ENGINEERING SERVICE TO THE IRON & STEEL INDUSTRY

When space is a problem, you want your heavy bus lines completely out of the way. The lightness of Alcoa Aluminum Busses makes it possible to put *them* in otherwise impractical places.

The structural strength of Channeluminum combined with its weight saving of 52%, makes unsupported spans of 25 feet perfectly practical, with no lessening of desirable factors of safety.

Either vertical or horizontal (yes even triangular) phase configuration is possible with simple fittings that are surprisingly inexpensive. Bends, turns, angles are all easily accomplished by bolting or welding, and taps and splices are simple, too.

The use of the familiar standard channel shape is a happy example of what economies can be accomplished with plain, straightforward solutions of perplexing problems. The plane surfaces simplify erection. The hollow square formed by the two channels provides the closest practical and economical approach to theoretical electrical efficiency, and has great advantages for both radiation and ventilation.

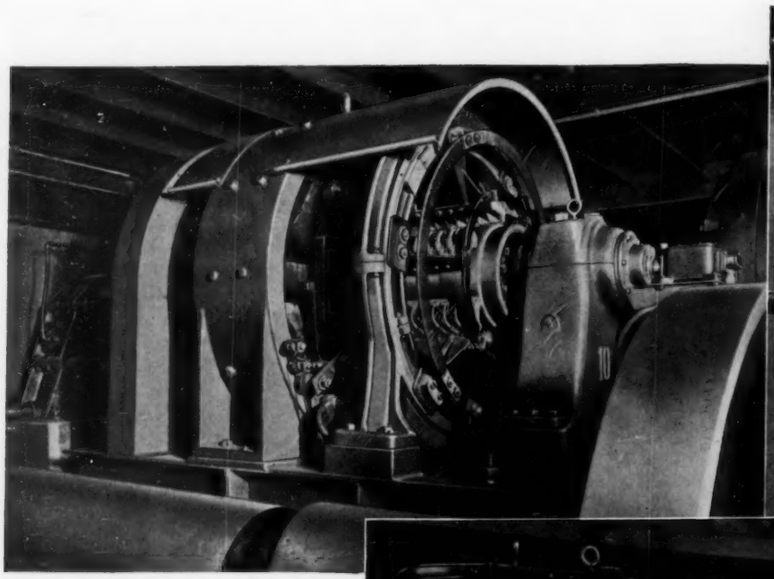
Combined in a system with Alcoa Aluminum Flats and Tubes for lighter loads, taps, load centers, Channeluminum is the ideal conductor for heavy steel mill loads.

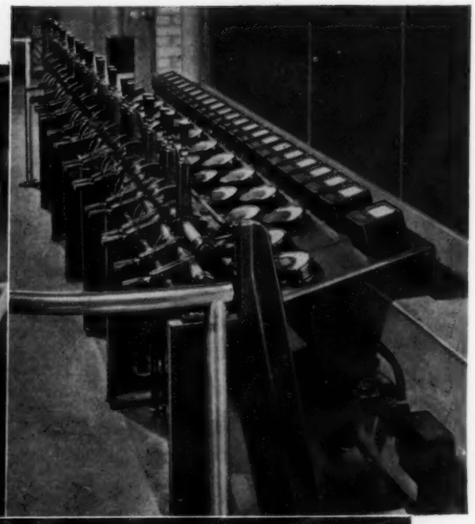
May we send you the whole story in our book, "Channeluminum Electrical Conductors of Alcoa Aluminum."

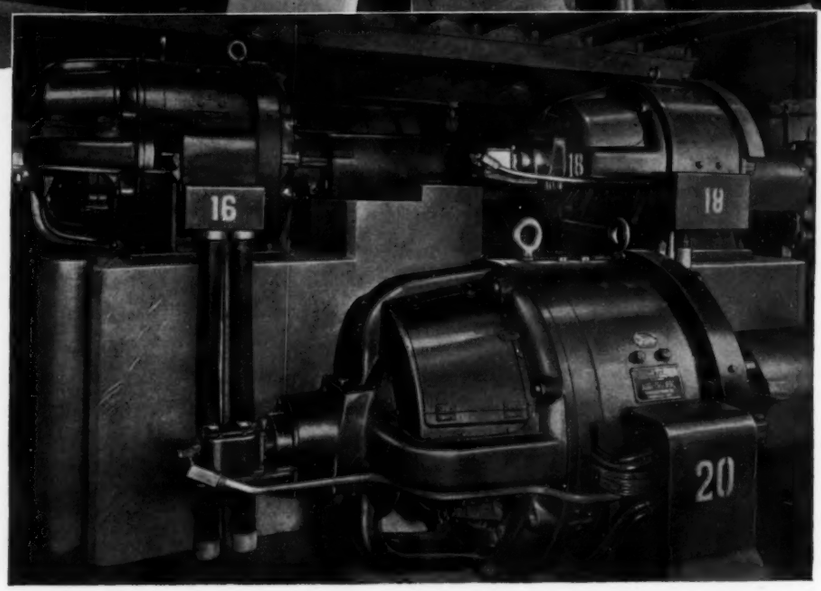
ALUMINUM COMPANY OF AMERICA
1828 GULF BUILDING, PITTSBURGH

ALCOA · ALUMINUM

A. I. & S. E. E.—TWENTY-SEVEN YEARS OF ENGINEERING SERVICE TO THE IRON & STEEL INDUSTRY







Above—Encased flywheel type, direct current motor of welded steel construction, driving a working roll of the 21-stand, continuous Foren mill at the plant of the Globe Steel Tubes Co., Milwaukee, Wis.

Above right—Pulpit control for coarse and fine speed adjustment of Foren mill. Rheostat operating levers, speed and main line current indicating meters shown.

Right—Three direct current motors, each driving a forming roll of the Foren mill.

Driving the New Foren Mill

IN a continuous process, various sizes and gauges of seamless tubing are rolled on a mandrel by the 21-stand Foren mill at the Milwaukee plant of the Globe Steel Tubes Co.

Because of the short center distances between consecutive stands, motors and control must be accurately co-ordinated to give proper speed regulation and insure reasonable division of loads.

Steel Mill engineers of the Allis-Chalmers Mfg. Co. are always ready to help solve your rolling mill problems. Call upon them when considering major or minor ideas affecting modern mill practices.

PRODUCTS FOR THE STEEL MILL

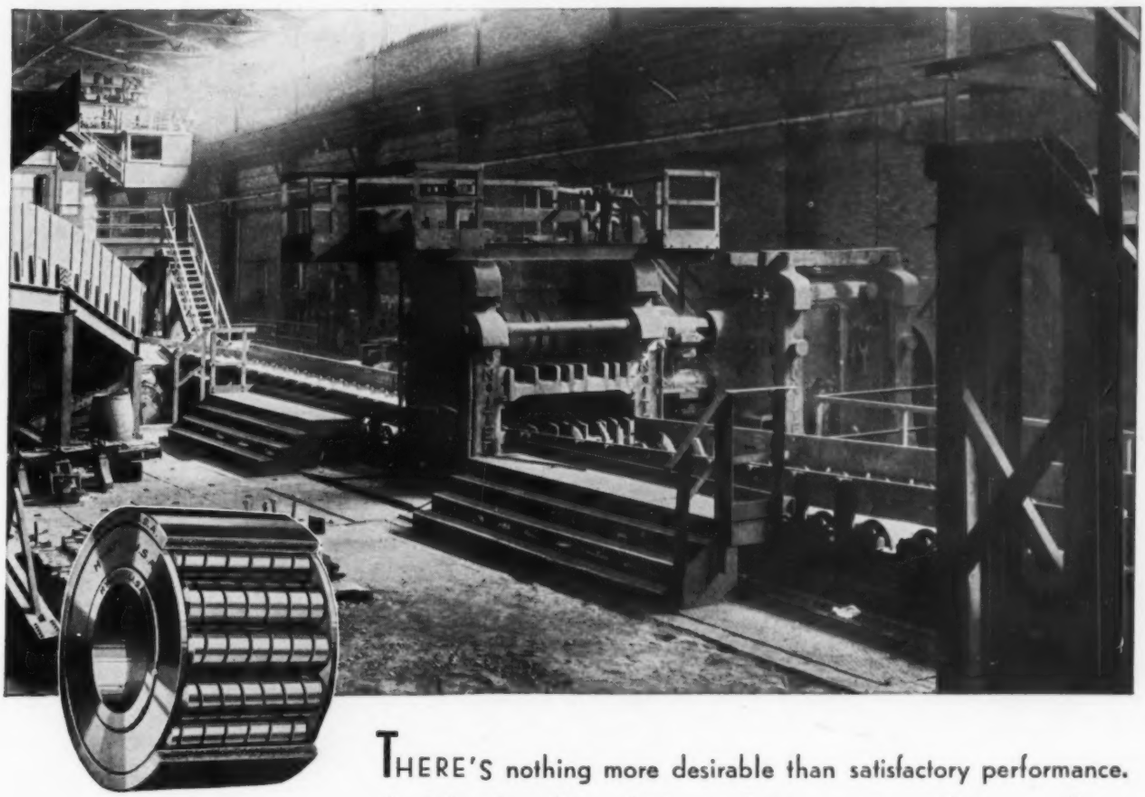
Main Roll Drives
General Purpose and Special Motors
Motor-Generator Sets
Mercury Arc Rectifiers
Switchboards — Transformers
Metal-clad Switchgear
Steam Turbine Units
Steam Engines — Condensers
Blast Furnace Gas Engines
Blowing Engines
Centrifugal Blowers
Rotary Compressors
Texrope V-Belt Drives

ALLIS-CHALMERS

Allis-Chalmers Manufacturing Company, Milwaukee

A. I. & S. E. E.—TWENTY-SEVEN YEARS OF ENGINEERING SERVICE TO THE IRON & STEEL INDUSTRY

PERFORMANCE INSURANCE



On the 28-inch Structural Mill at the Weirton Steel Company all tables are Hyatt Equipped. UNITED ENGINEERING & FOUNDRY COMPANY were the builders.

THERE'S nothing more desirable than satisfactory performance. And there's nothing which contributes more to satisfactory performance than proper bearings.

Not just a bearing to fit a hole, but the right bearing in the right place. That's the secret of how and why Hyatt Roller Bearings serve so well. The painstaking result of over 40 years of correct bearing design, quality manufacture and sound application.

In short, Hyatt Roller Bearings are designed, built and applied to give longer equipment life, dependable operation, and freedom from wear and care—to protect the vital working parts wherever they serve. Hyatt Roller Bearing Company, Newark, Detroit, Chicago, Pittsburgh, Oakland.

HYATT
ROLLER BEARINGS
PRODUCT OF GENERAL MOTORS

A. I. & S. E. E.—TWENTY-SEVEN YEARS OF ENGINEERING SERVICE TO THE IRON & STEEL INDUSTRY

Only 1 1/10¢ a year

Spent for

REPAIR PARTS

per horsepower controlled

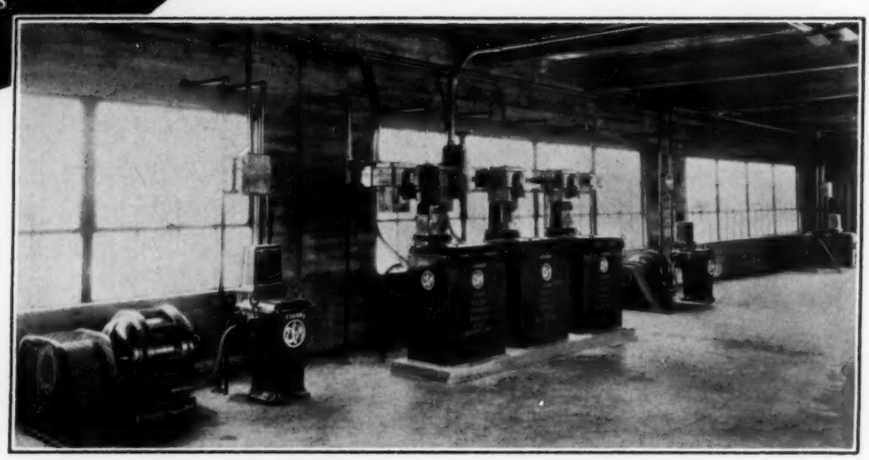
or

An average renewal part cost of

Only 12c a day

has kept over 150 EC&M Automatic Motor Starters in good condition

EC&M MOTOR STARTERS require infrequent attention—Many plants inspect them only once a year.



EC&M AUTOMATIC A.C. Motor Starters have every advantage for the user of electric motor-driven equipment. They are dust-proof and corrosion-proof. It is not necessary to build an expensive control room to house them. They can be installed out in the plant alongside the motors they control. And they are particularly easy to install, because they come to you as a totally enclosed, self-contained unit with all internal wiring complete. That they require minimum attention is proven by their low upkeep cost of operation. For example, dependable control for more than 4000 HP has been given by over 150 of these sturdily built units, six of which are shown in the above illustration. In this company's plant, the average length of service has been 6 years and yet, the repair part cost per horsepower controlled has been only 1-1/10c. a year. Write for descriptive literature illustrating these economical motor starters. Use the convenient coupon to the left.

MAIL THIS TODAY

The Electric Controller & Mfg. Co.
2700 East 79th St.
Cleveland, Ohio

Gentlemen:

Please send me your bulletin on
EC&M Low Voltage Compensators ☐
EC&M High Voltage Compensators ☐
EC&M Across-the-line Motor Starters ☐
Please show me the up-keep costs you have ☐

Name.....

Company.....

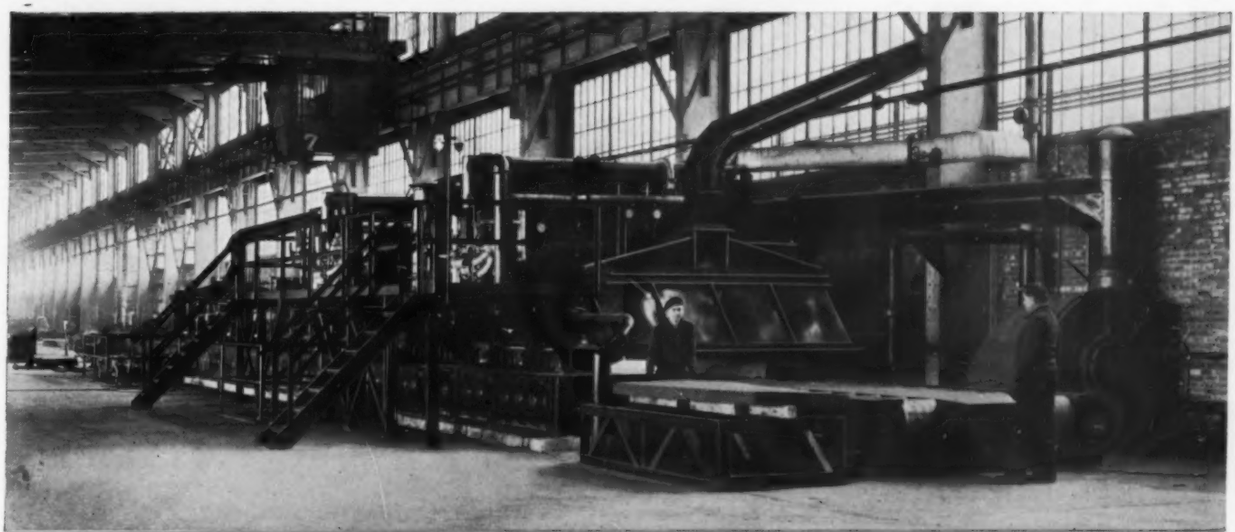
Address.....

I.&S.E. 12-34

THE ELECTRIC CONTROLLER & MFG. CO.

CLEVELAND, OHIO

NEW YORK-50 CHURCH ST.
CHICAGO-310 So. MICHIGAN AVE.
DETROIT-DIME BANK BLDG.
BIRMINGHAM-BROWN-MARX BLDG.
CINCINNATI-412 SYCAMORE ST.
ST. LOUIS-1027 CLAYTONIA TERRACE
SALT LAKE CITY-KEARNS BLDG.
DENVER-P.O. BOX 591.
HOUSTON-928 M&M. BLDG.
TORONTO-#2 NEVILLE PARK BLVD.
PHILADELPHIA-WITHERSPOON BLDG.
PITTSBURGH-OLIVER BLDG.
SAN FRANCISCO-420 MARKET ST.
LOS ANGELES-912 E. THIRD ST.
BUFFALO-888 COLVIN BLVD.
SEATTLE-2207-1ST AVE. So.



SC Continuous Sheet Normalizing Furnace equipped with the SC Oil Gasification system. The furnace actually becomes gas fired by this system which converts heavy fuel oil to gas.

SC Oil Gasification

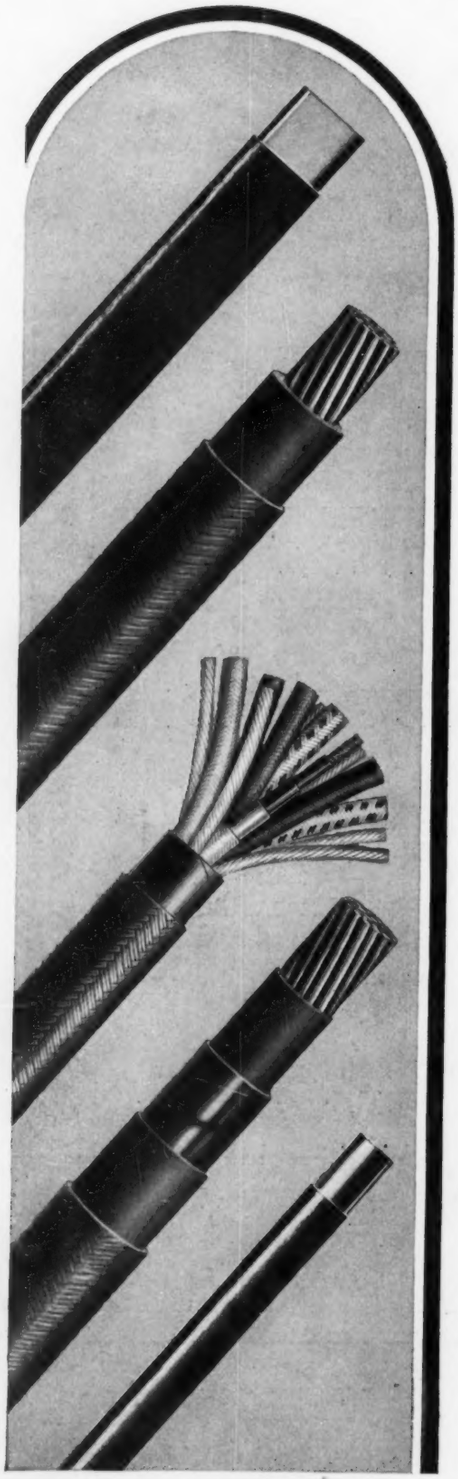
This development is another remarkable achievement by Surface Combustion. In this system heavy crude oil is actually converted into gas, giving the furnace all the advantage of gas heating. The furnace illustrated above has been in constant twenty-four hour a day operation for many months, definitely proving the advantages of oil gasification.

This high capacity furnace uses a specially designed alloy shaft type conveyor and is used for normalizing or blue annealing. It will permit high speed travel through the cooling chamber, irrespective of the rate of travel through the heating zone. This is desirable in controlling the temperature at which blue annealed material is roller leveled.

Surface Combustion Corporation

TOLEDO, OHIO Sales and Engineering Service in Principal Cities

Whether for ingot, billet, rod, wire, tube, bar, sheet, or tin plate, we will be glad to help you plan the most modern and efficient equipment to best perform your heating operation. SC Soaking Pits, Slab or Billet Heaters, Pack or Pair Furnaces, Normalizers and Annealing Furnaces are correctly designed, engineered and built for the individual requirement.



THERE ARE

Deltabeston

ASBESTOS-INSULATED WIRES FOR EVERY PURPOSE

General Electric manufactures a complete line of Deltabeston Asbestos Insulated Wires and Cables. They are made of the highest-quality materials and by a unique process. The high percentage of inorganic material contained in the insulation assures maximum resistance to heat. For that reason, Deltabeston Wire is unexcelled in performance where heat is a factor. The illustrations show a few Deltabeston Wires and Cables particularly suitable for application in the iron and steel industry.

Constant research and experimentation are being made in the effort to improve their quality and performance. For information on the complete line of Deltabeston Asbestos Insulated Wires and Cables see your G-E Merchandise Distributor or Graybar Electric Co., or write Section Y-2412, Merchandise Department, General Electric Co., Bridgeport, Connecticut.

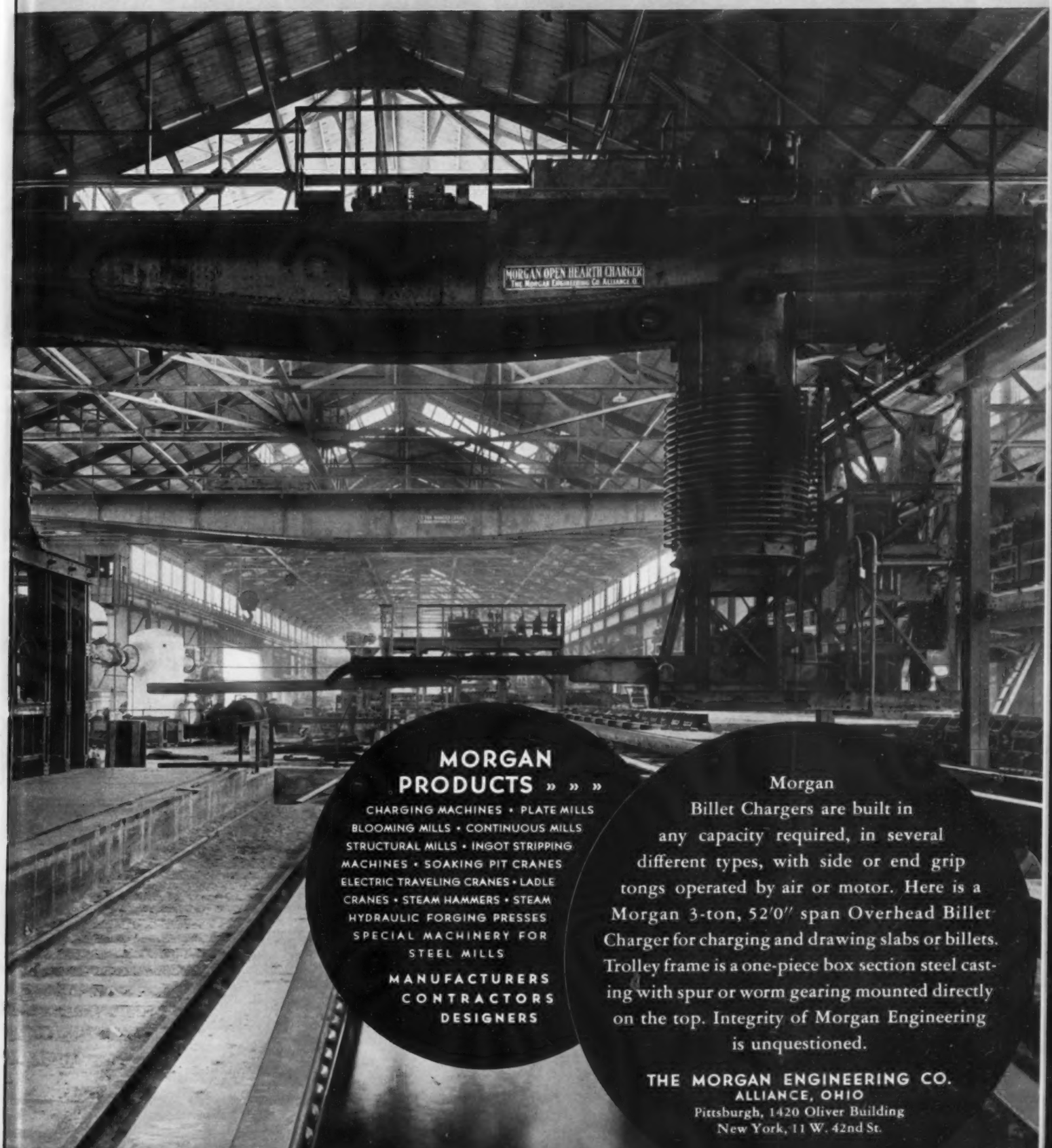
NRA U.S. CODE

GENERAL ELECTRIC

DELTABESTON WIRE AND CABLE

MERCHANDISE DEPARTMENT, GENERAL ELECTRIC COMPANY, BRIDGEPORT, CONNECTICUT

BUILT BY MORGAN *Engineering* » »



MORGAN PRODUCTS » » »

CHARGING MACHINES • PLATE MILLS
BLOOMING MILLS • CONTINUOUS MILLS
STRUCTURAL MILLS • INGOT STRIPPING
MACHINES • SOAKING PIT CRANES
ELECTRIC TRAVELING CRANES • LADLE
CRANES • STEAM HAMMERS • STEAM
HYDRAULIC FORGING PRESSES
SPECIAL MACHINERY FOR
STEEL MILLS

MANUFACTURERS
CONTRACTORS
DESIGNERS

Morgan Billet Chargers are built in any capacity required, in several different types, with side or end grip tongs operated by air or motor. Here is a Morgan 3-ton, 52′0″ span Overhead Billet Charger for charging and drawing slabs or billets. Trolley frame is a one-piece box section steel casting with spur or worm gearing mounted directly on the top. Integrity of Morgan Engineering is unquestioned.

THE MORGAN ENGINEERING CO.
ALLIANCE, OHIO
Pittsburgh, 1420 Oliver Building
New York, 11 W. 42nd St.

THE AMCO RECUPERATOR

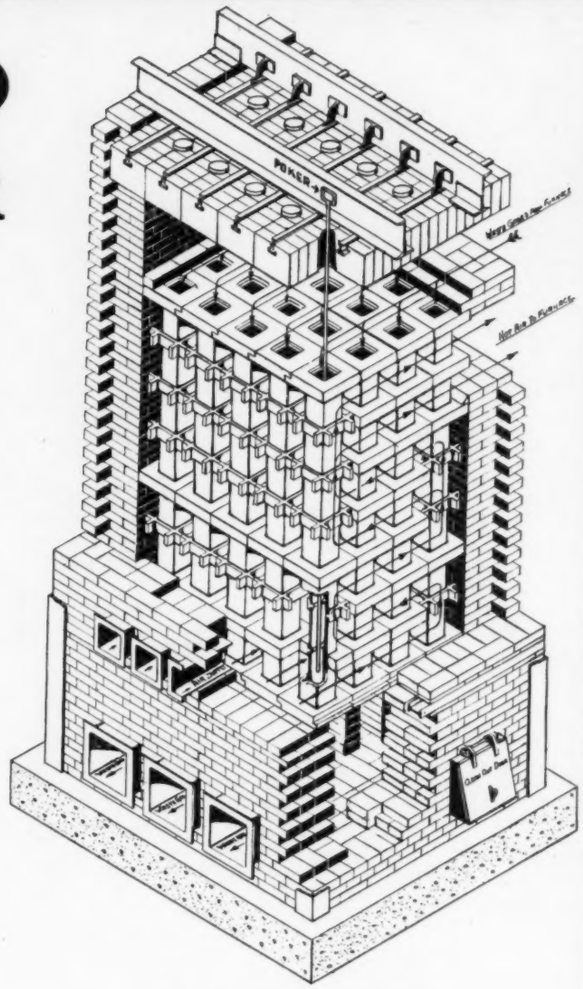
✦

Used in many types of Furnaces for preheating Combustion air.

✦

First recuperator built 12 years ago and still in operation.

✦



SECTION THROUGH
AMCO RECUPERATOR

SALIENT POINTS OF AMCO RECUPERATOR

1. Made of spaced apart Refractory Tile to permit uniform heating.
2. Self-sealing—all joints horizontal.
3. All waste gas and preheated air move within tile setting, thus insuring higher preheat temperatures and more effective use of space.
4. Waste gas enters all tubes simultaneously, thus eliminating "initial shock"—permitting perfect counter cooling.
5. Recuperator may be cleaned while in operation.
6. May be applied to existing Furnaces.

Send for Bulletin describing AMCO Recuperator and Soaking Pit

THE AMSLER-MORTON COMPANY

FULTON BUILDING PITTSBURGH, PA.

Amsler-Morton—G.M.B.H BERLIN | AMCO—KTG SHEFFIELD | AMCO BARCELONA | Fours et Fumisterie Industrielle PARIS

NO HOURS COST AS MUCH AS "STOPPED" HOURS

The secret of Jefferson Super-Lag performance lies in the lag plate which is a part of the Super-Lag link. This plate delays the normal fuse action, provides a time interval or lag. This time-lag prevents the fuse from blowing on harmless temporary overloads—saves needless shutdowns and link replacements.

The cost of getting back to normal running efficiency makes STOPPED hours the most costly hours. Some stops cannot be avoided—but many are needless now that there are fuses which protect TIME along with motors.

Jefferson Super-Lag Renewable Fuses protect time because of their lag method of overload protection of motors. Harmless momentary overloads or surges are not permitted to stop the machines—yet on dangerous prolonged overloads the motors are cut from the line and saved.

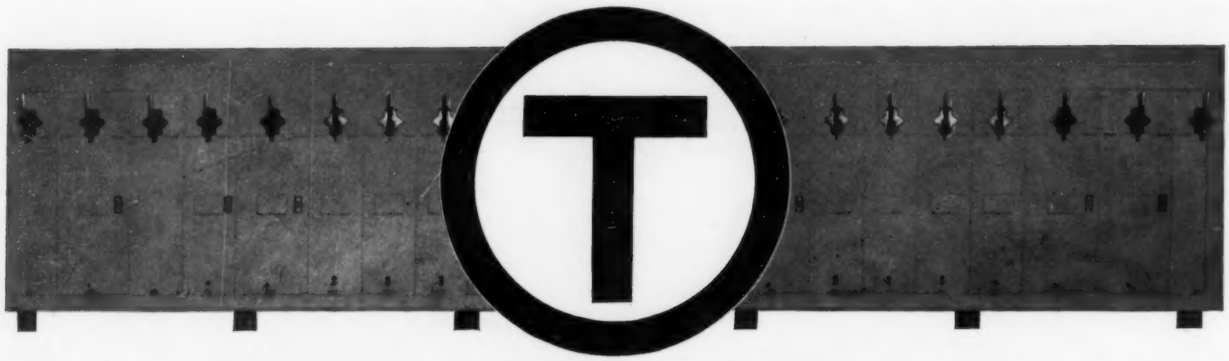
There is no better protection for electrical equipment and property—no better protection against STOPPED HOURS. Made in all capacities, knife blade and ferrule types. Start reducing your STOPPED HOUR Losses by specifying Jefferson Super-Lag Fuses.

Fuse Chart—FREE—A handy Guide to selection of proper size fuses at a glance, for the adequate protection of motors. Ask for Fuse Chart No. 21.

JEFFERSON ELECTRIC COMPANY

BELLWOOD (Suburb of Chicago) ILLINOIS

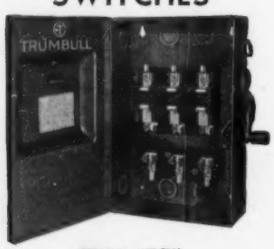
JEFFERSON Super-Lag RENEWABLE FUSES



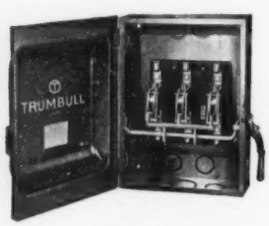
CUT POWER DISTRIBUTION COSTS

with "Circle T" Equipment

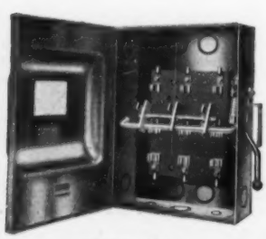
SWITCHES



TYPE "RB"
Side and front operated.
Interlocking safety cover.
Vystipe fuse clamps.
Break full rated load.



TYPE "A"
30-2400 Amps.
Interlocking safety cover.
Break full rated load.



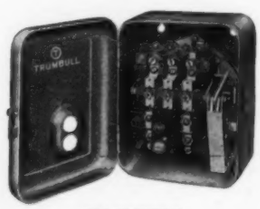
TYPE "C"
Non-interlocking cover.
Break full rated load.
Also Type "D" switches for disconnect service only.

Illustration at top shows a centralized control front operated interlocking (F.O.I.) distribution board for industrial service. Disconnect switch and magnetic contactor are combined in one unit for each circuit with a common bus.

- Nothing is more important than electrical switchboards, power and lighting panels, safety switches, motor starters and other distribution equipment in analyzing power costs. Consideration of these items is imperative in checking factory production.
- Production may be stepped up, costs decreased, both from an operating and maintenance standpoint, by installing new, or revamping existing power distribution systems.
- Let us suggest layouts or check your specifications to show you how the Trumbull all-inclusive line of electrical control from the main switchboard to the last motor or lighting switch will cut power costs.
- There are many types of "Circle T" control items not mentioned here to meet varying plant conditions. All are described in Trumbull catalogs and bulletins. Copies gladly sent on request.

STARTERS

MANUAL
Type TM-2 Max. rating 2 H. P.
Surface or flush mounting.
Manual starters with overload protection available in ratings up to 7½ H. P.



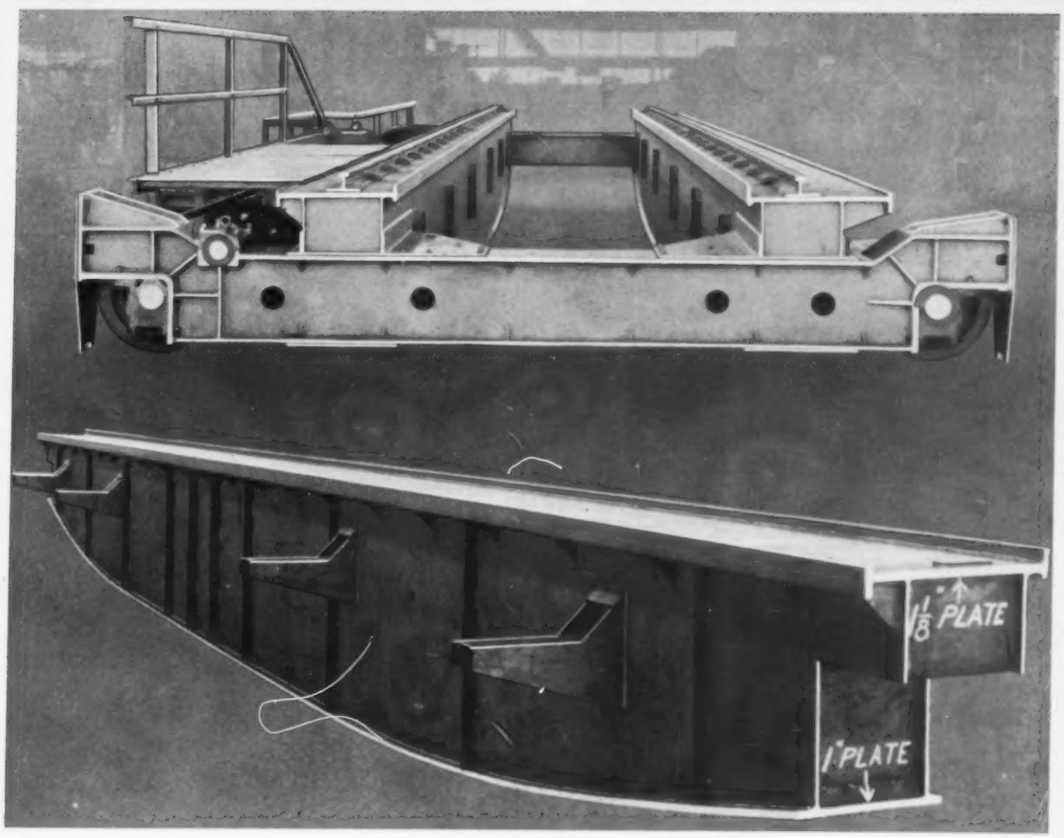
MAGNETIC
Across-the-line starting.
Time limit overload protection.
Undervoltage protection.
Capacities up to 25 H. P.

No fuse or fusible safety switch disconnect combined in one cabinet with magnetic starter having interlocking cover.

THE TRUMBULL ELECTRIC MFG. CO.

PLAINVILLE, A GENERAL ELECTRIC ORGANIZATION CONN.

BUILDERS OF STEEL MILL CRANES OF STEEL MILL STEEL



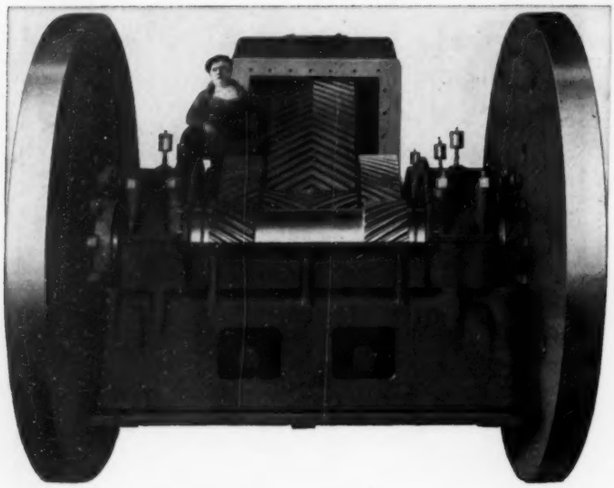
A bridge for a 10 ton soaking pit crane with Cleveland All Welded Girders and End Trucks.

also Builders of CLEVELAND TRAMRAIL MATERIALS HANDLING SYSTEMS

5200 Cranes have been built by Cleveland in 35 years. This well fits us to meet your most exacting modernizing requirements.

THE CLEVELAND CRANE & ENGINEERING CO.
NEW YORK DETROIT WICKLIFFE OHIO PITTSBURG CHICAGO

CLEVELAND CRANES
All Sizes for Every Service



DON'T WASTE POWER

"The Gear with a Backbone"

transmits power with highest efficiency

The drive illustrated above is an example of the solution by Farrel-Birmingham engineers of a rolling mill drive problem involving the application of anti-friction bearings to a heavy duty drive for steel mill service.

This double reduction gear unit is, so far as we are able to ascertain, the largest **completely** anti-frictionized gear drive ever built. Both the high and low speed shafts are mounted on Timken roller bearings.

It has been in operation for the past five years driving a sheet mill in the plant of the Allegheny Steel Company and giving dependable, economical service. It transmits 1600 H.P., with peaks of 5500 H.P., at a motor speed of 360 R.P.M., and has a ratio of 12 to 1. The roller bearings on the low speed shaft are 23" bore. The flywheels weigh 30 tons and operate at 11,500 feet per minute peripheral speed. The entire unit weighs over 130 tons.

This drive is typical of the advanced design incorporated in Farrel-Sykes gear units and is indicative of the unusual engineering and plant facilities for the production of gears and gear units.

If some of your drives are noisy, if they vibrate, if the gears and bearings are worn, if they require continual maintenance, you can be sure they are inefficient, costly wasters of power and money. Better call in Farrel-Birmingham engineers and get their recommendations on gear units that will reduce power transmission costs to a minimum.

FARREL-BIRMINGHAM
COMPANY, INC.
366 Vulcan Street, Buffalo, N. Y.

Your 1935 Advertising Plans

Undoubtedly you are now making your 1935 advertising plans. May we urge your earnest consideration of the Iron and Steel Engineer in your 1935 advertising plans.

In the last five years the executives who read the Iron and Steel Engineer have assisted in the purchase of more than $500,000,000.00 worth of Mechanical, Electrical, Lubrication, Combustion, Safety and Welding Equipment and Maintenance materials used in the Iron and Steel Industry.

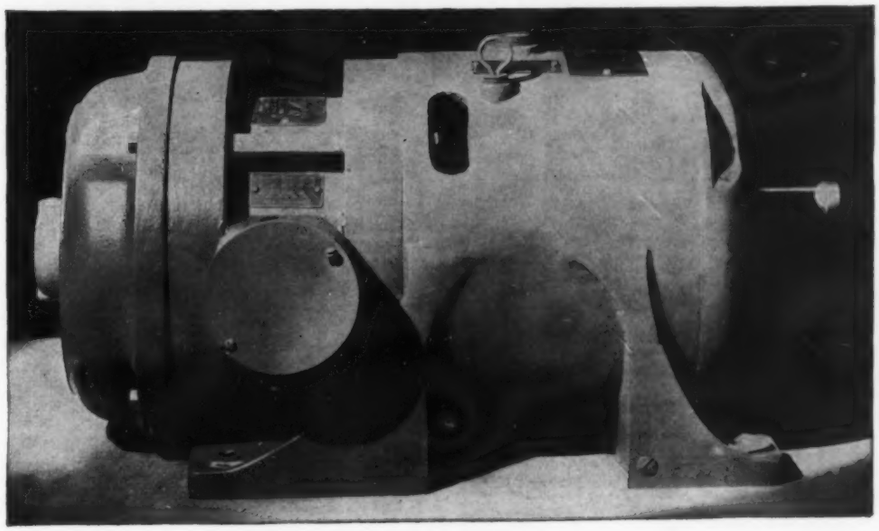
Use The Iron and Steel Engineer To Reach These Executives.

1935 ADVERTISING RATES

	One Time	Six Times	Twelve Times
One Half Page	$45.00	$37.50	$35.00
One Page	$75.00	$55.00	$50.00

$20 Extra per Page for One Additional Color

RELIANCE GEARMOTOR (*A-C. Squirrel-cage Motor—Double reduction*)



STRENGTH TO MATCH STEEL-MILL NEEDS

IN developing these combined units we have kept before us a useful question—one that has influenced Reliance Design for many years—"Will the iron and steel men okay it?"

One result is very apparent—general ruggedness.

All units have substantial feet cast integral with the gear housing. There's proper support and ample strength in the right place to withstand shocks and pounding on tough jobs.

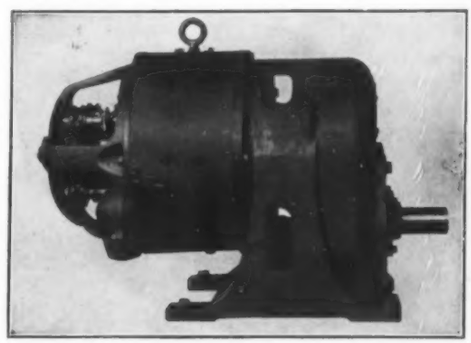
A simple train of helical gears is used. In double and triple-reduction gearmotors, a cartridge-type gear unit carries all gears and bearings except the high-speed pinion. The cartridge can be readily removed without disturbing the alignment of any gears or bearings.

Further interesting details are given in our Bulletins 400 and 402. Read them and keep in mind the "Checking points" listed herein.

Use these checking points

In considering gearmotors, you will naturally wonder how variations in individual designs may affect you from the standpoint of installation, maintenance, change of location, length of service, etc. We suggest a check of these points.

Ease of taking apart and assembly.
Simplicity of design (gear train, bearings).
Position and strength of support.
Ease of ratio change.
Location of output shaft.
Lubrication (checking oil level, protection from leakage into motor unit).
Kind and quality of gears.



Type S Reliance GearMotor with single reduction as used for ratios up to 6:1, inclusive. D-c. motor can be used for constant or adjustable-speed service.

RELIANCE A-C D-C MOTORS

RELIANCE ELECTRIC & ENGINEERING CO.

1080 IVANHOE ROAD CLEVELAND, OHIO

Branches: BIRMINGHAM, BOSTON, BUFFALO, CHICAGO, CINCINNATI, DETROIT, NEW YORK, PHILADELPHIA, PITTSBURGH, WASHINGTON.

A. I. & S. E. E.—TWENTY-SEVEN YEARS OF ENGINEERING SERVICE TO THE IRON & STEEL INDUSTRY

Savings are Important Now!

SAVINGS was the keynote of practically every paper submitted at the Iron and Steel Convention. Here is a report from a steel plant that tells a concise story of how NON-FLUID OIL saves money in ring-oiling type bearings—

"We are forwarding under separate cover sample of NON-FLUID OIL which has been in service 9½ months. Formerly we had to add ⅛ of a pint daily —since using NON-FLUID OIL we have not had to replenish the oil in the bearings, nor have we had any trouble with overheating as in the past."

This letter really tells you the whole story of NON-FLUID OIL—"The dripless, wasteless modern lubricant"—that saves money on lubricant cost and cost of application.

Find out by test what savings NON-FLUID OIL will make in your plant. Write today for free testing sample and full information.

New York & New Jersey Lubricant Co.
Main Office: 292 Madison Ave., New York, N.Y.

WAREHOUSES:

Chicago, Ill.	Providence, R. I.	Atlanta, Ga.
St. Louis, Mo.	Detroit, Mich.	Charlotte, N. C.
New Orleans, La.	Spartanburg, S. C.	Greenville, S. C.

TRADE MARK REGISTERED
NON-FLUID OIL
IN U.S. PAT OFFICE & FOREIGN COUNTRIES

MODERN STEEL MILL LUBRICANT

Better Lubrication at Less Cost per Month

RADIATORS

ACCESSIBLE

for cleaning or painting

All radiators on Pennsylvania Power Transformers are permanently welded to tank and each radiator has a single row of tubes, which are easily accessible for cleaning or painting, a distinguished feature of Pennsylvania construction.

We are meeting the needs of the largest industrials with a complete line of power and distribution transformers. Write.

Pennsylvania Transformer Co.
1627 ISLAND AVE., N. S., PITTSBURGH, PA.

PENNSYLVANIA TRANSFORMERS

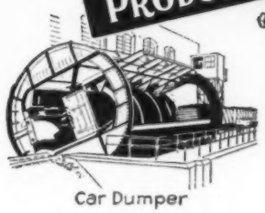
DISTRIBUTION AND POWER

Wellman

Leading steel producers throughout the world have found the time-tested facilities of this long established engineering organization an ally in carrying out programs for more efficient production and lower operating costs

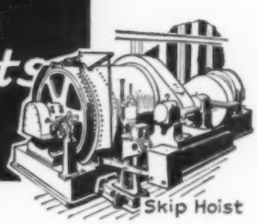
-an ally to those who must cut costs

MACHINERY FOR IRON AND STEEL PRODUCTION



Car Dumper

Charging Machine



Skip Hoist

We also specialize in the Designing, Building and Perfecting of SPECIAL MACHINERY to master unusual production problems and cut production costs.

● ● ● WELLMAN Products Include:

Car Dumpers, all types
Charging Machines and Manipulators
Coke Oven Machinery
Gas Producers, Flues, etc.
Gas Reversing Valves
Mining Machinery
Safety Stops for Traveling Structures
Special Cranes
Steel and Tube Mill Equipment
Williams Buckets and Trailers
Castings and Machine Work to customers' drawings

THE WELLMAN ENGINEERING CO.
ENGINEERS CONSTRUCTORS MANUFACTURERS
CLEVELAND, OHIO
BIRMINGHAM • NEW YORK • MEXICO CITY

"There's NO SUCH THING AS Cheaper Wire!"

"Listen, I've been through the mill. I've 'saved money' on my wiring requisitions for the last time. When we started keeping our figures on the basis of *service life* instead of *first cost* I got an awful shock!"

This plant electrician was converted to ROCKBESTOS when he discovered that the inconvenience and expense of periodic replacement could be traced directly to his "cheaper wire" and was *not* an "act of God" to be endured with more or less patience and fortitude.

ROCKBESTOS A. V. C. wire is ideal for all severe operating conditions. Its insulation is a felted and impregnated wall of asbestos in which is embedded a high dielectric insert of varnished cambric to provide ample margin of safety under wet conditions. This A. V. C. insulation is heat-proof and moisture resisting, unaffected by corrosive fumes and will not bloom when attacked by oil or grease.

It costs money to replace wire—not to mention the cost of time out or stopped production. You can avoid that expense by using ROCKBESTOS A. V. C. wires and cables. Even if your circuits are not now subjected to severe conditions, bear in mind that plant changes may so expose them at some future time. ROCKBESTOS A. V. C. wires are always a good investment. Wouldn't you like to test a sample? The coupon will bring one. Fill it out and mail it today. ROCKBESTOS PRODUCTS CORPORATION, New Haven, Conn.

ROCKBESTOS
—the wire with permanent insulation

ROCKBESTOS PRODUCTS CORP.
New Haven, Conn.

I'd like to look over a piece of A. V. C. wire.

Signed.....

Company.....

City..... State.....

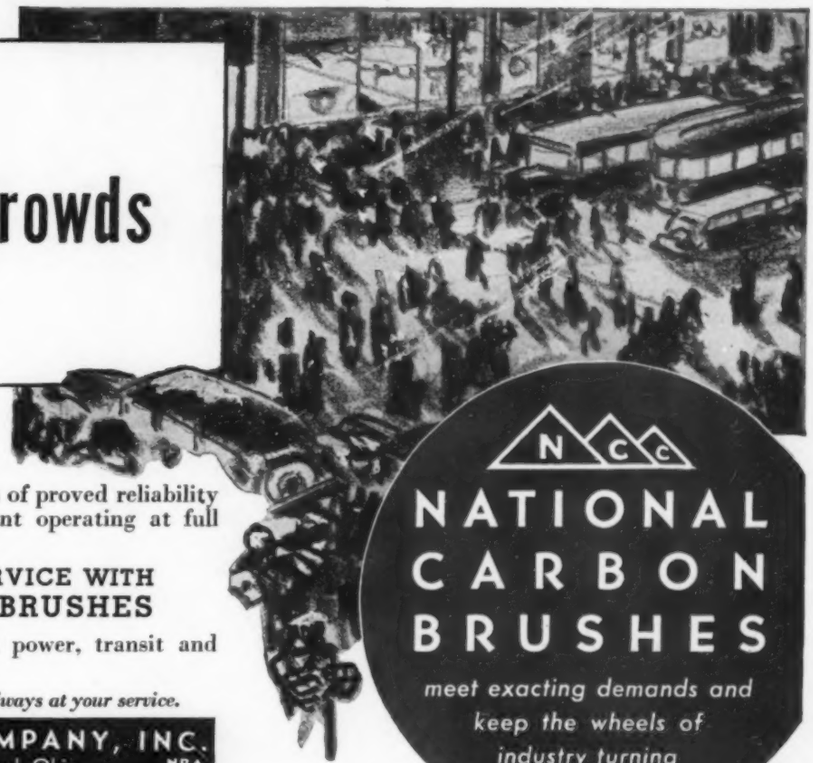
Stimple & Ward Co., Inc.

Manufacturers of Very High Grade Armature and Stator Coils in all Voltages

PITTSBURGH, PA.
SINCE 1898

Special Emergency Service

When Christmas Crowds Clamor



POWER and transportation facilities are taxed to the limit of capacity. Continuous service is essential. Brushes of proved reliability are needed to keep electrical equipment operating at full efficiency.

INSURE CONTINUOUS SERVICE WITH NATIONAL CARBON BRUSHES

They have proved their reliability on power, transit and industrial equipment.

Our thoroughly trained representatives are always at your service.

NATIONAL CARBON COMPANY, INC.
Carbon Sales Division, Cleveland, Ohio
Unit of Union Carbide UCC and Carbon Corporation
Branch Sales Offices: New York • Pittsburgh • Chicago • San Francisco

NCC
NATIONAL CARBON BRUSHES
meet exacting demands and keep the wheels of industry turning

LARGEST BUILDERS OF THE WORLD'S LARGEST CRANES

Alliance Products

STANDARD CRANES
Up to 430 tons capacity

STRIPPING CRANES
Up to 320 tons capacity

COMBINATION CHARGERS and STRIPPERS
Up to 200 tons capacity

- Ladle Cranes
- Ingot Strippers
- Soaking Pit Cranes
- Open Hearth Charging Machines
- Slab and Billet Charging and Drawing Machines
- Gantry Cranes
- Ore and Coal Bridges
- Car Dumpers
- Forging Manipulators
- Steam Drop Forge Hammers
- Coke Pushers, Levelers and Door Lifters
- Coal Pier Equipment
- Rolling Mill Machinery
- Cement Plant Machinery
- Dock Handling Equipment
- Coke Oven Equipment

275 of 100 Tons Capacity and over

LADLE AND STANDARD CRANES

59		100 tons
2	WORM DRIVEN Ladle,	100 tons
2		115 tons
6	WORM DRIVEN Ladle,	125 tons
45		125 tons
30		150 tons
3	WORM DRIVEN Ladle,	150 tons
6	WORM DRIVEN Ladle,	160 tons
2	WORM DRIVEN Ladle,	165 tons
7	WORM DRIVEN Ladle,	175 tons
27		175 tons
3	WORM DRIVEN Ladle,	200 tons
4		200 tons
5		225 tons
1		250 tons
3	WORM DRIVEN Ladle,	250 tons
3	WORM DRIVEN Ladle,	275 tons
1		275 tons
1		300 tons
3		430 tons

STRIPPING CRANES

8		100 tons
1		125 tons
22		150 tons
19		200 tons
1	Single Ram,	320 tons

COMBINATION CHARGERS AND STRIPPERS

3		100 tons
1		125 tons
3		150 tons
4		200 tons

Give Us the Runway and We will Lift the World

THE ALLIANCE MACHINE CO.
ALLIANCE, OHIO, U.S.A.
ENGINEERS AND BUILDERS

MARTINDALE

WISHES YOU—ONE AND ALL

Merry Christmas

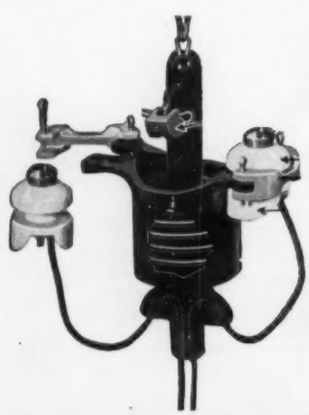
and

THE MARTINDALE ELECTRIC CO.

1377 HIRD STREET, (LAKEWOOD) + CLEVELAND, OHIO, U. S. A.

ANOTHER IMPROVEMENT IN THOMPSON LAMP LOWERING HANGERS

—provides for wiring lower contact-elements to the reflector instead of building them into the lower member of the Hanger—quick and easy installation—reflectors interchangeable without re-wiring—contact-elements securely fastened in holders, yet readily demountable without disturbing wiring connections—permits socket repairs to be made in shop where suitable facilities are available.



Gravity Suspension Attachment No. 137 makes Hangers and Lamps self-aligning in vertical position, when attached to irregular overhead support.

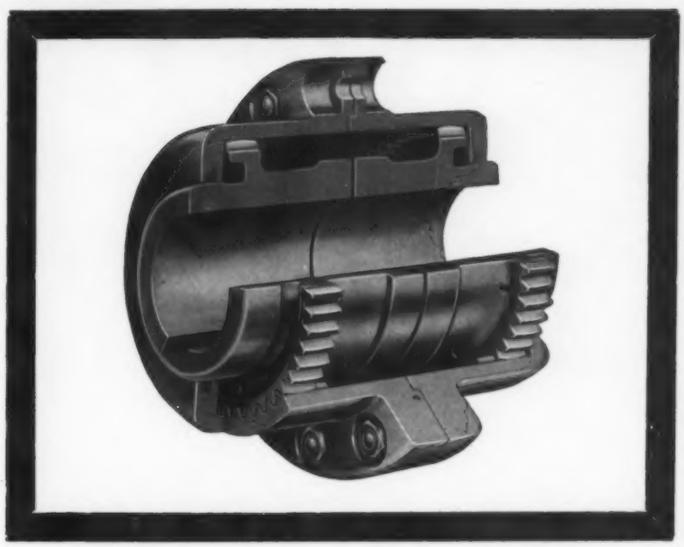
Still Another Improvement—hereafter the iron latching parts in all THOMPSON HANGERS will be Cadmium plated, for protection against corrosion.

GET PRICES ON THESE NEW DEVELOPMENTS.

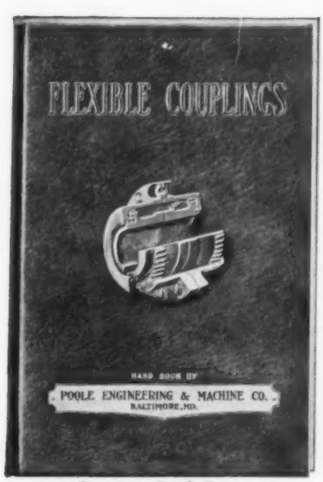
THE THOMPSON ELECTRIC CO.

1101 Power Ave., N. E. Cleveland, O., U. S. A.
Note New Address

POOLE



. . . *the better* Flexible Coupling



Get the Real Facts
Write for our Catalog No. 34
No obligations

It gives full compensation for the unavoidable errors in alignment or those caused by changes of temperature, wear of bearings, vibration, etc. It also permits free lateral float to connected shafts, and prevents torsional motions.

Stronger than the connecting shafts. Capable of sudden reversals at high speed or heavy duty, slow speed drives without strain to the coupling or the machinery it connects. Simple in design, no springs, pins or bushings, self-aligning, silent and vibrationless at all times.

Exclusive features and improvements found in no other coupling distinguish the POOLE FLEXIBLE COUPLING as the superior product in its field.

POOLE FOUNDRY & MACHINE CO.
BALTIMORE, MD.

CLEVELAND, OHIO
G. H. Bales,
Rockefeller Bldg.

BIRMINGHAM, ALA.
McVey-Hausman Co.,
2019 6th Ave. North

PITTSBURGH, PA.
Ladd Equipment Co.,
First National Bank

CHICAGO, ILL.
Reitz Sales Co.,
549 W. Washington St.

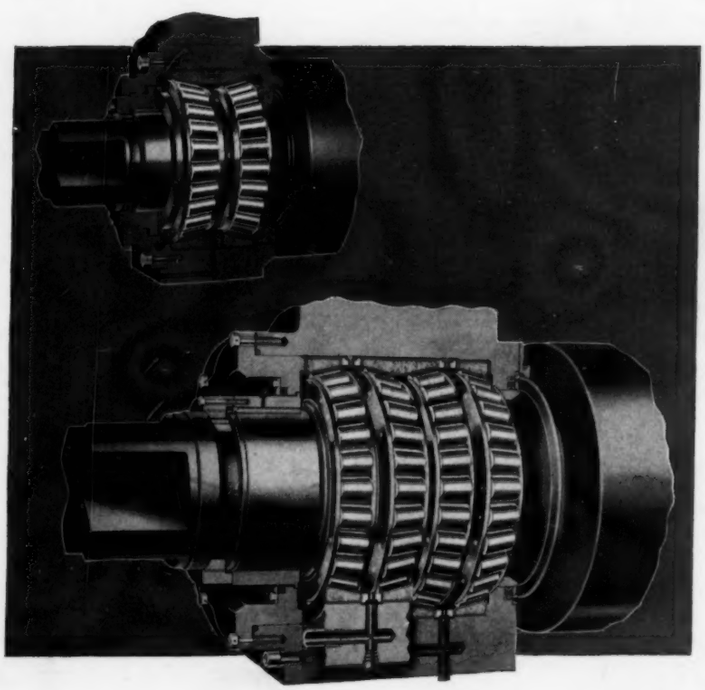
600,000 TONS

and still going strong

MANY Timken Roll Neck Bearings installed during the last five years have rolled more than 600,000 tons of hot sheets—and look good for hundreds of thousands of tons more.

Careful records kept by many mill operators show that bearing maintenance costs have sunk almost to the vanishing point per ton of steel rolled.

Such outstanding performance records and economies are now history with Timken. But, you ask, why do Timken Bearings show such a pronounced superiority in comparison with other types of roll neck bearings? The answer is found in Timken design and Timken's 12 years of specialized engineering experience with roll neck bearings. There is no substitute for that combination on mill roll necks.



THE TIMKEN ROLLER BEARING COMPANY, CANTON, OHIO

TIMKEN *Tapered Roller* **BEARINGS**

A. I. & S. E. E.—TWENTY-SEVEN YEARS OF ENGINEERING SERVICE TO THE IRON & STEEL INDUSTRY